Oldman River Dam

Alberta
ENVIRONMENT

A STRATEGY FOR FISHERIES MITIGATION IN THE OLDMAN RIVER BASIN

VOLUME I
UPSTREAM COMPONENT

prepared for

ALBERTA ENVIRONMENT
PLANNING DIVISION
and
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prepared by

DOMINION ECOLOGICAL CONSULTING LTD.

in association with

JNMACKENZIE ENGINEERING LTD.

APRIL 1988

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GLOSSARY OF TERMS

G.S.C.	Geodetic Survey of Canada
$S.M_3$	Square Meters
dam^3	Cubic Decameter
ha	Hectare
km	Kilometer
km/h	Kilometer per Hour
m	Meter
kt	Kilotonnes
kt/a	Kilotonnes per annum
cms	Cubic Meters per Second

OLDMAN RIVER DAM PROJECT
FISH SPECIES LISTING

Common Name	Scientific Name
SPORT FISH	
Rainbow trout	Salmo gairdneri Richardson
Brown trout	Salmo trutta Linnaeus
Cutthroat trout	Salmo clarki Richardson
Bull trout	Salvelinus malma (Walbaum)
Lake trout	Salvelinus namaycush (Walbaum)
Mountain whitefish	Prosopium williamsoni (Girard)
Lake whitefish	Coregonus clupeaformis (Mitchill)
Burbot	Lota lota (Linnaeus)
Walleye	Stizostedion vitreum vitreum (Mitchill)
Sauger	Stizostedion canadense (Smith)
Mooneye	Hiodon tergisus Lesueur
Northern pike	Esox lucius Linnaeus
COARSE & FORAGE FISH	
Longnose sucker	Catostomus catostomus (Forster)
White sucker	Catostomus commersoni (Lacepede)
Longnose dace	Rhinichthys cataractae (Valenciennes)
Lake chub	Couesius plumbeus (Agassiz)
Trout perch	Percopsis omiscomaycus (Walbaum)
Spoonhead sculpin	Cottus ricei (Nelson)

ACKNOWLEDGEMENTS

The study team gratefully acknowledges the support and assistance of the following persons in the course of this project:

Mr. Doug Hagerman and Mr. Walter Solodzuk served as Project Managers and contributed significant advice and materials needed for our research. Mr. B. Kemper, Mr. J. Englert. Ms. A. Trimbee and Mr. R. Middleton, Alberta Environment, Planning Division provided background research studies and also contributed useful advice regarding past studies completed in the area.

Mssrs. A. Ambrock, A. Locke and W. Griffiths, Alberta Fish and Wildlife Division, provided guidance and advice regarding approaches to the study.

Mr. John McCulloch of Trout Unlimited made available materials on construction/implementation costs of stream remedial methodologies employed by that agency.

The Oldman River Dam Project Fish and Wildlife Sub-Committee graciously took time to participate with the Study Team in a field inspection of sites in the area and a subsequent informal information meeting held at Pincher Creek. The Chairman, Mr. Dennis Olson, kindly provided minutes and associated materials from previous meetings.

A special word of thanks is due to Mr. Lorne Fitch, Alberta Fish and Wildlife Division Lethbridge, for his kind and extensive participation in both the field and office components of the study.

Dr. R. Crowther contributed the technical appendix and literature review dealing with nutrient enhancement methodologies for cold water rivers.

While the authors gratefully acknowledge the kind assistance of those persons noted above, we assume full responsibility for the content of this Fisheries Mitigation Strategy.

EXECUTIVE

SUMMARY

FOREWORD

Attached herewith is the report entitled "A Strategy for Fisheries Mitigation in the Oldman River Basin - Volume 1, Upstream Component. This volume represents the culmination of three years of field and technical evaluations of the fisheries of the Oldman River Basin. The Strategy is a careful plan designed to fully address the upstream mitigation process necessary to meet the goal of the Alberta Government to achieve "no net loss of recreational fisheries opportunity". In order to attain the objective, Alberta Environment has assembled and fielded one of the largest contingents of fisheries scientists, hydrological engineers and basin planners ever used on a project in Canada. This team has completed some of the most detailed fish population and habitat surveys ever undertaken in the Province, particularly in the Crowsnest, Castle and Oldman Rivers.

The Strategy deals principally with upstream components but also considers downstream areas as part of a phased approach to a fisheries mitigation strategy. A detailed fisheries mitigation strategy for the reservoir and downstream components will be dealt with in more detail in a volume which is presently under development. This second volume will take into consideration the different fish species and habitat downstream, and the new regulated and assured flows in those reachs of the river.

The base of data now assembled provides a substantive environmental assessment of existing fish habitat and populations from which exacting predictions as to the levels of effect have been derived. Throughout, close liaison with the local Fish and Wildlife Sub-Committee was maintained. Their comments which endorse this strategy are incorporated in this final draft. Our planning team is greatly encourag-

ed as to the feasibility of the strategy which has already been demonstrated in early stages through the inter-disciplinary cooperation of project engineers and fishery biologists.

In order to properly address the losses in fish habitat, which will result from the inundation of riverine areas, our team first quantified those areas and then set out a strategy to compensate for losses by the enhancement of habitat in upstream zones. The fish habitat and population analyses were extremely rigorous: comparisons were made between lost and surveyed habitat only, not the total habitat in the system. Data on fish habitat, by life stage and species, were converted to habitat classification units with general hydrologic and substrate characteristics. These data were subsequently assessed as to their potential for various types of physical mitigation.

An Intensive Study Area was designated for specific reaches of the Crowsnest River as a first phase in the implementation of the Fisheries Mitigation Strategy. A Pilot Project for fisheries habitat enhancement was constructed at three sites in the fall of 1987 and will be evaluated for suitability in engineering and fish habitat parameters, on a continuing basis. Thirteen additional sites will be constructed in 1988, and each successive series of habitat improvements will be re-evaluated during each stage of the implementation process. This phased approach to mitigation (both engineering and biological), will ensure that the structures deployed will be exhaustively assessed and proved effective to achieve and maintain the appropriate levels of fisheries mitigation. In addition to the quantitative (habitat) approaches to be used, qualitative measures are presently being carefully assessed. These methods enhance secondary riverine productivity in order to increase the overall standing crop of recreational fishes in rivers of

lower productivity, like the Castle River.

This package of habitat enhancement techniques is among the most ambitious undertakings of fisheries habitat mitigation in Canada. Other similar habitat enhancement structures previously constructed in the Crowsnest River at Blairmore (near our Intensive Study Area) have increased trout populations by more than 500%. Such impressive scientific results have led our research team, Alberta Fish and Wildlife Division personnel and the Municipal District of Pincher Creek Fish and Wildlife Sub-Committee of the Local Advisory Committee to conclude that a responsible Fisheries Mitigation Plan can, indeed, be achieved in the Oldman River Basin. A major factor contributing to our confidence in the Strategy is the stated commitment by government to on-going biological and engineering evaluations of the structures as they are built. Since a carefully phased approach has been adopted, the effectiveness of the techniques employed will be measured to ensure that the objectives for fisheries mitigation are achieved and maintained. Throughout, we recognized that if physical habitat modifications are to achieve a lasting value they must be designed to incorporate sound principles of river engineering. These works must compliment the natural stream configuration, which further requires careful site-specific fishery and engineering evaluations. An element crucial to the success of the strategy is the commitment for continuous evaluations of the efficacy of the proposed mitigation techniques. This will ensure that mitigation is realized in the river basin. The Mitigation Plan, based on this strategy, will achieve the flexibility necessary to fulfill the commitment by government to the preservation and maintenance of this important sport fish and recreation resource.

SUMMARY

At the time of writing of this report, the Government of Alberta is actively constructing a water storage and flow regulation dam on the Oldman River near Pincher Creek. It has been recognized that the project will have a significant impact on the existing habitat for valued sportfish in the region, and the Government of Alberta committed itself to develop a fisheries mitigation plan to attain a condition of "no net loss of recreational fishing opportunity as a result of dam construction."

"A strategy For Fisheries Mitigation in the Oldman River Basin Final Report" is a strategy for the mitigation of fisheries habitat lost chiefly in the upstream reaches of the Oldman River Basin; containing general strategies for the downstream and reservoir areas. This study was structured as a series of steps, each of which progressively led to a better definition of the options, or strategies, for fisheries mitigation. This work is heavily dependent on field work previously (and currently being) carried out for Alberta Environment.

First, those field data were used to develop quantitative estimates of the riverine fishery habitat lost to the reservoir, in specific reaches of the Oldman River Basin. Second, fisheries habitat areas in the Basin, which were potentially available for attempts at mitigation, were evaluated from the above noted literature and in an aerial reconnaissance. Fish habitat data, by life stage and species, were converted to habitat classification units defined by physical parameters (hydraulic and substrate characteristics) for ease of application. Third, various techniques for mitigation were suggested as being feasible in broad reaches of the study area.

An Interim Report on the strategy for fisheries mitigation in the Oldman River Basin was issued in June, 1987 for scrutiny by the Municipal District Fish and Wildlife Sub-committee chaired by Mr. Denis Olson.

In 1987, extensive fisheries habitat and population studies were undertaken in the upper reaches of the basin in the Crowsnest, Castle and Oldman Rivers. These studies significantly augmented work undertaken previously on this fishery and those results have been incorporated in this Final Draft of the Mitigation Strategy.

In the Fall of 1987, three fisheries mitigation projects were designed and constructed in an area of the Crowsnest River which was designated as an Intensive Study Area. Fish populations in the area were intensively sampled prior to construction and these will be further monitored in order to assess the population responses to the structures built.

While the field work, mitigation construction and habitat mapping was being done, detailed liaison with the Fish and Wildlife Sub-Committee was maintained. Their comments and concerns regarding priorities for, and techniques in, fisheries mitigation were incorporated in this Mitigation Strategy. These activities encourage the planning team as to the feasibility of these plans and demonstrate the capability of engineers and biologists to provide an inter-disciplinary team approach to mitigation. Further, detailed cost estimates are now being developed in order to arrive at long-range implementation planning for the strategy.

The Pilot Project undertaken in the Intensive Study Area, exemplifies the government's commitment to the philosophy of mitigation and demonstrates the types of fisheries enhancement which can be achieved in the river basin.

Throughout the time of our investigations it was recognized that this Mitigation Strategy would be primarily a scoping study from which a list of feasible options could be selected and eventually implemented. Site-specific engineering plans have been developed and implemented in the Intensive Study Area and 13 new sites will be built in 1988. New data on habitat availability and fish populations, particularly in the upstream tributaries, will be obtained throughout upcoming field seasons in order to further implement the strategy. Clearly, decisions as to the degree and extent of fisheries mitigation projects to be constructed rests with appropriate government departments, which have already demonstrated a significant commitment to work with local residents and interest groups in achieving satisfactory remediation.

It must be borne in mind that any estimates of the scope and extent of fisheries mitigation required will be greatly influenced by the assumptions used in approaching the problem, not the least of which is a precise definition of "no net loss of recreational fishing opportunity". **Here, the team take this to mean chiefly the replacement, above Full Supply Level (FSL), of the high quality riverine fishery habitat which will be lost to flooding but also including the mitigation of impacts on downstream fish populations.**

The primary assumptions, all of which were carefully evolved in consultation with the appropriate agencies and individuals, are listed below. It is noted that these assumptions lay the basis for a rigorous, worst-case approach to fisheries mitigation in both the assessment and implementation phases of the Strategy:

- **Riverine fishery habitat lost will be replaced by other riverine fishery habitat where possible (through mitigation) and not by a reservoir fishery.**

- In order to evaluate the potential loss of fish due to the reservoir, the actual losses of high quality habitat will equate to fish lost.

- Wherever possible, the habitat to be replaced for each sport fish species and life stage will be implemented on sections of the same stream upstream of FSL as was lost below FSL.

- The high quality of fish habitat lost to flooding of the Oldman River mainstem is not wholly attributable to the Oldman North Fork for mitigation purposes. It has been decided that apportionment of mitigation strategies will be most effectively focused on the Crowsnest River.

- In order to carry out the physical enhancement techniques it will be necessary to upgrade habitat of a lower quality to higher grades. Inter-specific trade-offs among fishes will be necessary and the following species priorities were confirmed for the Study Team:

  (c) trout has priority over mountain whitefish on all three upstream rivers

  (b) on the Crowsnest River brown trout has priority over rainbow trout (below Lundbreck Falls)

  (c) habitat areas will be maintained or enhanced for selected riverine areas below the dam

- The methodology employed has been to mitigate the maximum amount of lost habitat for the area within the surveyed data base.

- With respect to spawning areas lost below FSL, this study

has used the data provided on specific spawning sites actually utilized rather than the mapped habitat area data on potential spawning areas.

- Overwintering sites lost below FSL were not mitigated for above FSL since the existing assessments assume that the reservoir will provide overwintering habitat for the major sport fish species.

- The mitigative options proposed for the reservoir and downstream of the reservoir are only conceptual at this time, and firmer options will only be possible when the water regime, water temperature and water quality of the reservoir and the resulting downstream flows are finalized.

- Ultimate decisions on the proportional allocation of funding for mitigation between the geographic zones of the Oldman River Basin will be made by the Government of Alberta.

Each of these study assumptions exert a significant influence on the conclusions of our study and therefore, must be examined with great care, and their ramifications clearly understood.

When the reservoir is filled, the Crowsnest, Castle and Oldman North Fork rivers will lose 9.1, 12.2 and 6.4 km, of riverine habitat, respectively, in addition to the losses in the Oldman River mainstem. Downstream, changes in water quality (chiefly temperature) and hydrology will change fish habitat immediately below the dam although these aspects are still being investigated in more detail. The dam will block fish passage upstream. Affected chiefly will be mountain whitefish and, to a lesser extent, rainbow trout.

In order to quantify the existing amounts and types of fisheries habitat to be lost, the team adopted the habitat classification system used in previous studies for the region, one which incorporates measures of water depth, velocity and substrate type. The habitat surveys made available to our study team prior to June 1987 extended from the dam site upstream to approximately twice the length of the flooded area at FSL. The detailed mapping component of the surveys extended from the dam site to the reservoir FSL (with the exception of the Crowsnest which extended to Lundbreck Falls). The fisheries habitat database has since been significantly expanded and the data incorporated into this report. The expanded habitat survey carried out in the summer of 1987 extended the coverage upstream to Crowsnest Lake on the Crowsnest River, to Livingstone Pass on the Oldman North Fork, and to the junction of the Westcastle and Southcastle Rivers on the Castle. Therefore, although it is still not possible to consider all available headwater habitat above FSL, the fish habitat coverage is now very extensive in the upper basin. A summary of riverine habitat lost is shown overleaf:

SUMMARY OF HABITAT LOST BY INUNDATION

SPECIES	LIFESTAGE	TOTAL HABITAT (1) (square metres)	HABITAT LOST (square metres)	% LOST
Rainbow	Juvenile	1,520,281	226,865	15%
Trout	Adult	297,779	224,676	75%
Brown	Juvenile	70,204	29,098	41%
Trout	Adult	35,051	20,950	60%
Mountain	Juvenile	2,981,469	413,574	14%
Whitefish	Adult	1,569,659	979,243	62%

(1) Note: Total habitat refers to the total surveyed fisheries habitat in the Oldman River System upstream of the dam as of December, 1987. We stress that the comparison is between lost habitat and the surveyed habitat, not the total habitat in the system. Hence, our analysis of affected habitat is considered to be conservative.

These data demonstrate that the reservoir will reduce the amount and type of natural sport fish habitat, and sport fishing opportunity, in a region of exceptionally valued recreational fishing opportunity and capability.

In order to properly address these losses in habitat, and to devise adequate mitigation plans, the team adopted a pragmatic and direct approach to fishing mitigation. Data on fish habitat, by life stage and species, were converted by us to habitat classification units with general hydrologic and substrate characteristics. We subsequently assessed these data as to the potential for different kinds of phys-

ical mitigation techniques.

Our previous consultations had established that upstream riverine mitigation was considered to be the highest priority in achieving a mitigation strategy. The next priority was for mitigation efforts to be applied downstream of the dam. There was little support found for a reservoir fishery to compensate for riverine fish and habitat losses. The consultations with government officials and local residents focused the work and helped to better define the assumptions used in our study.

While it is known that physical conditions within river channels can be modified so as to improve the fishery habitat, and fish populations, it must be recognized that if such modifications are to achieve permanence they must be designed using sound principles of river engineering. Poorly planned and executed structures may actually cause more damage, in terms of lost habitat, to the natural stream. Further, any engineering works must complement the natural stream configuration, which implies a need for careful site-specific biologic and engineering evaluations, well in advance of in-stream construction. This construction activity must be planned to minimize associated damage to adjacent habitat areas and must be timed to avoid impacts on fish spawning or incubation periods. Hence, local ecological sensitivities and biological cycles for fish populations must be incorporated into the final engineering planning for any site-specific engineering techniques which may be employed.

As a rule, sport fish production in the Oldman River Basin, above the dam site, is much higher in the Crowsnest River than the Castle or Oldman North Fork Rivers. This difference is presumably a result of a combination of abiotic and biotic limiting conditions. From the available

habitat surveys on the three main tributaries it appears that there is, or at least was at the time of the surveys, suitable habitat in the Castle and Oldman North Fork Rivers that was not being utilized to full potential. This usually leads to a conclusion that biotic factors, such as inadequate food supply, might be responsible for under-utilization in those reaches.

There are major differences between the upstream rivers in terms of flow regime. One element of the flow regime, which has a strong influence on habitat availability and stability, is the probability of the occasional flood event which can destroy or create habitat. The Castle River exhibits higher extreme flow events than the Oldman North Fork River, which in turn exceeds the values for the Crowsnest River. Hence, since fish habitat is closely related to flow regime, it is likely that some degree of abiotic constraint must exist in the Castle and Oldman North Fork Rivers at least in comparison to the Crowsnest River. It is possible that the habitat on the former two rivers is less stable and/or that fish utilization is being limited by food supply.

The habitat lost for rainbow trout due to inundation by the reservoir must be compensated for within both the surveyed data base area above FSL and in other minor tributaries. The lost habitat for brown trout can, in theory, be mitigated above FSL within the surveyed reach of the Crowsnest River. As rainbow and brown trout were the priority species for our mitigation strategy we have accordingly focused our efforts on those species.

The team believes that a pragmatic approach to fisheries habitat mitigation upstream of the reservoir would be to utilize the entire Oldman River system above the reservoir, including headwater sections that are suitable for upgrading. A brief aerial reconnaissance was done in order to

identify specific areas for potential mitigation. While not definitive, the sites identified and presented in our report are locations of prime interest for further site-specific evaluation and engineering.

Three specific mitigative techniques have been selected for habitat mitigation upstream of the full supply level of the reservoir. These are as follows:

1) In fast, shallow, river runs, narrow the channel and provide ledges and meanders to reduce the slope and deepen the water. Install bank overhang on the pools at bends.

2) In the slow, shallow, river runs, narrow the channel and provide instream riffles and boulder gardens.

3) The addition of instream cover throughout the river systems by the placement of boulder gardens.

During the aerial reconnaissance, specific potential mitigation sites were identified for each of the Castle, Crowsnest, and Oldman North Fork Rivers. The results of the reconnaissance are not definitive, but do present site-specific river reaches which should be examined further as to specific mitigative works and their design.

For the Castle, Crowsnest and Oldman North Fork Rivers, the team identified three, seven, and two potential areas for site-specific mitigation, respectively.

The team concludes, based on the habitat and fisheries data reports completed to date, that the Oldman River Dam will significantly impact a large portion of the sport fish habitat available within the Oldman River Basin. In summary the

key issues are as follows:

- The impoundment behind the dam will cause a significant loss of adult holding habitat on all three upstream streams for all three sport fish species assessed, and rearing habitat for brown trout on the Crowsnest. No significant losses are anticipated to occur for utilized spawning sites for the trout species.

- Rainbow trout, brown trout and mountain whitefish are the major sport fish species in the affected area, with mountain whitefish being the most abundant.

- The Crowsnest River constitutes the most important habitat for, and source of, rainbow and brown trout among the rivers which have been evaluated.

- Upstream mitigation techniques are suggested to provide rearing and adult habitat for trout, by the technique of upgrading lower quality riverine habitat sites. Although some of the habitat areas which have been slated for potential upgrading have been used by mountain whitefish, no great losses in the mountain whitefish populations are expected as indicated by the existing literature. This is because it is currently expected that the mountain whitefish will be able to co-utilize the mitigated habitat which is developed in our plan.

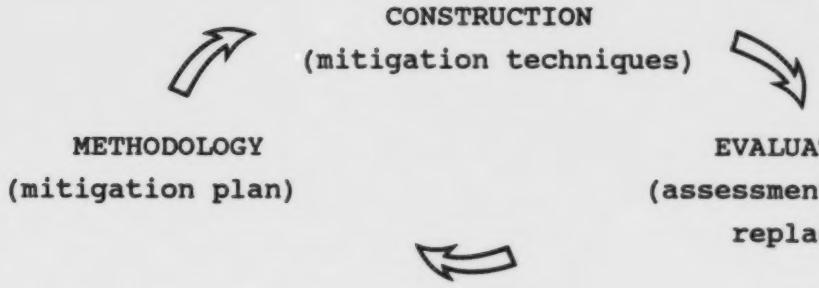
- Nutrient enrichment, in the form of artificial fertilization through the use of decaying detritus, could be an approach to increasing the low sport fish densities in the Castle River. This river exhibits characteristics of low detrital content, due to the coniferous nature of the head water reaches. A research program is currently being undertaken to evaluate the effect of artificial fertilization on the Castle River. Artificial fertiliza-

tion is not recommended for consideration in the Crowsnest River because these waters already have high existing phosphorous levels.

- Downstream of the dam, physical changes in the expected stream flows and water temperature regimes, accompanied with expected riverbed changes, will likely alter habitat and affect on the sport fish populations. In addition, populations will be dissected by the physical presence of the dam and upstream movements past the dam will obviously not be possible. Hence the dam presents a major barrier to upstream migration to spawning grounds for the mountain whitefish and rainbow trout residing in those river sections. However, the reduction of spring freshet flows and stable (and generally increased minimum flows) average flows throughout the rest of the year, will probably be beneficial to fish populations downstream in the long run, particularly to mountain whitefish. Further work is being undertaken to ascertain the type and degree of expected riverine changes, and this should aid the selection of appropriate mitigation strategies.

- The development of a viable reservoir fishery is not given a high priority by local residents, or Fish & Wildlife Division personnel. If it was attempted, stocking of sport fish would be necessary while coarse fish species would tend to dominate reservoir populations. The construction of sub-impoundments to the main reservoir, which are divorced from the detrimental effects of summer water level drawdowns, is one possible option to provide additional stocked fisheries. However, we consider that these options probably are prohibitively expensive and that funds would probably yield far better results if allocated to riverine enhancements in upstream areas.

- The evaluation of the biological efficacy of proposed mitigation techniques is crucial if one is to properly judge the mitigation proposed. Further, without such post-construction evaluations it will not be possible to ascertain whether or not the commitment for a "no net loss" situation has been met by the mitigation measures which have been implemented.



The schematic diagram represents the process which will be necessary to implement and verify the overall mitigation plan, the success of which must be measured using biological criteria. The stream and fishery improvements resulting from these in-stream works must be such that they will either survive the decay of those structures or be regularly maintained.

- Preliminary evaluations for, and tests of, potential mitigation techniques, particularly in upstream areas, have been initiated in pilot projects. This approach using pilot phased works should be methodically employed in the plan. Significant refinements and evaluations could therefore be made for potential mitigation methodologies during the construction phase of the project. The results from these continuing evaluations will greatly enhance the eventual large-scale implementation of techniques once the FSL is achieved.

- In order to implement the various mitigation options outlined in this plan it will be necessary to allocate the proportion of mitigation (of the 100% habitat area required to achieve "no net loss") to each of the three geographic (upstream, reservoir and downstream) zones. This decision constitutes one of strategy and extends beyond biological or engineering considerations.

  (a) Upstream

  (i) 15.5 km of the Oldman mainstem will lose significant amounts of critical fisheries habitat. In order to mitigate for these losses upstream of the FSL it will be necessary to decide as to how much (area by life stage) mitigation should be applied in each of the three upstream tributaries.

  (ii) If techniques for artificial fertilization are to be tested in the Castle River, it will have to be decided whether such an enhancement would constitute part of the "no net loss" equation.

  (b) Reservoir

  If the reservoir is to be used as a component of the mitigation strategy the fish species for stocking will have to be decided upon. Further questions of access and safety will need to be addressed.

  (c) Downstream

  Downstream mitigation planning for fisheries has now begun and the requisite water quality and fishery data are presently being assembled. The water

temperature regime of the reservoir outlet, which is presently judged to be inimical to rainbow trout spawning, will have to be carefully considered in any scheme. Other options could include use of other spawning channels downstream, a change in the trout species or use of hatchery stock to overcome spawning losses. The ongoing work should aid in selecting the appropriate options.

The following recommendations were made in June 1987 in order to facilitate early implementation of our suggested mitigation strategy:

1. Detailed fishery habitat mapping of those streams outside the influence of the impoundment should be completed in order to better define site-specific locations where it is possible to undertake mitigation. This work should be focused on the presently unmapped sections of the three main upstream tributaries . An important consideration is access for both the construction equipment and anglers.

2. Data on sportfish populations, on the streams above the full supply level of the reservoir, should be assembled immediately as a pre-dam baseline. This will require further surveys soon. These data will serve as the baseline against which the biological success of the mitigation techniques can be evaluated.

3. Fishery habitat mitigation techniques should be evaluated as to their degree of success. The evaluation should be planned so as to cover possible natural fluctuations in sportfish populations. If the physical techniques recommended in the mitigation plan are implemented soon in the upstream area, repeated evaluation could occur before project completion.

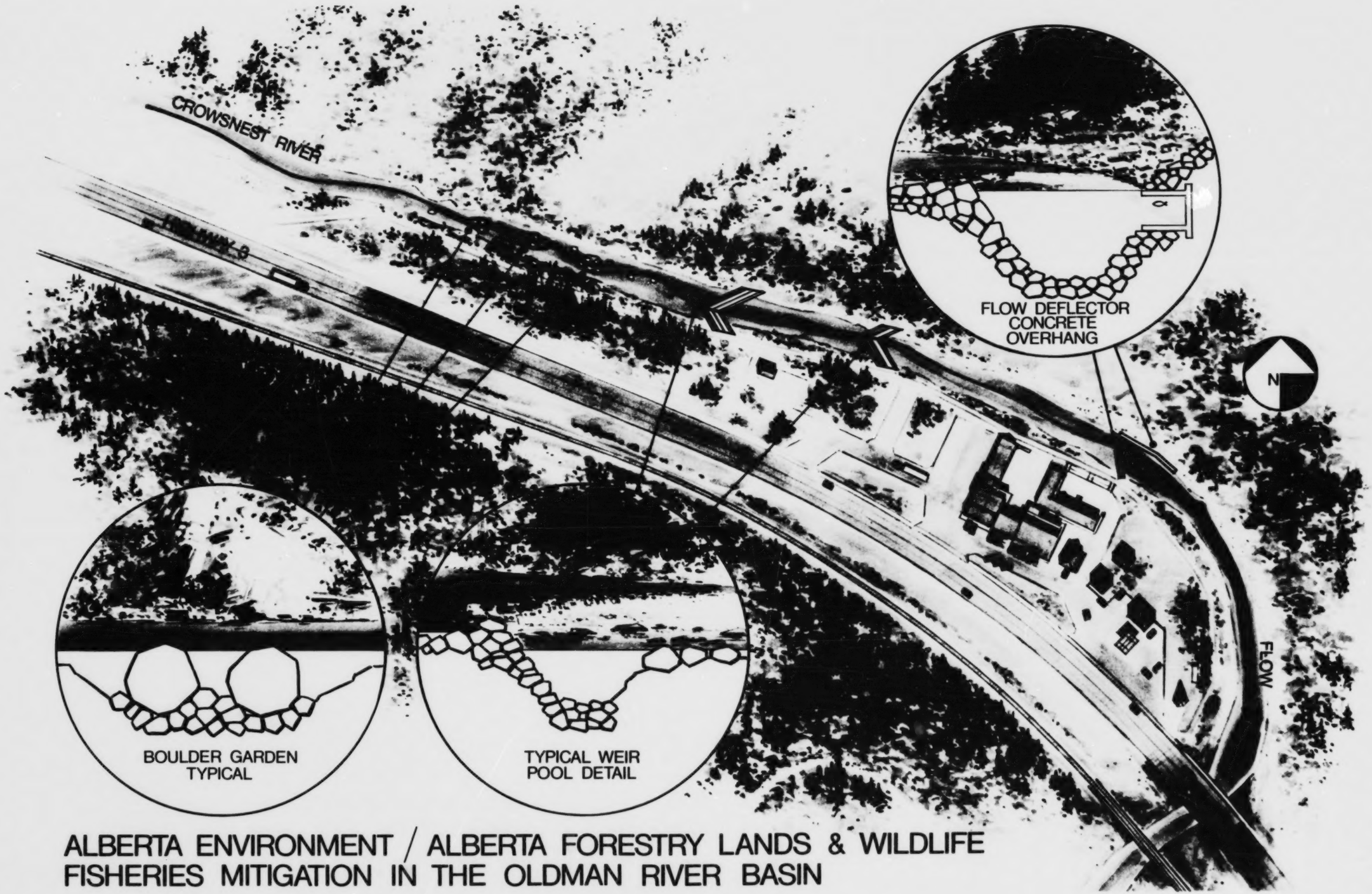
4. A pilot or test study of artificial fertilization (using decaying detritus) should be considered for the Castle River. A full evaluation of such work should be incorporated into the mitigation planning, with the realization that sufficient time will be needed to realize the full potential from nutrient enrichment to be achieved.

The above recommendations have been fulfilled.

In 1987, a comprehensive series of field studies was undertaken by teams of fisheries research scientists. These studies fulfilled the spirit and scientific intent of the above-noted recommendations and allowed for much more detailed planning in the Fisheries Mitigation Strategy. As a result of these, and parallel investigations, structures were evaluated and constructed in the Intensive Study Area during 1987. These structures will be followed with further construction throughout 1988. The principles of mitigation so demonstrated will allow for a phased and considered approach to mitigation planning throughout the Oldman River Basin.

A demonstration of the degree and extent of Fisheries Mitigation planning achieved in 1987 is presented on the figure overleaf showing the constructed sites in the Intensive Study Area on the Crowsnest River.

1. Physical modification of riverine habitat to increase its value to the fisheries resource should be designed on firm river engineering principles. Poorly planned and/or executed works may actually cause more damage in terms of lost habitat than they mitigate. Design of physical mitigative works should be a joint undertaking by biological and engineering specialists, in order to properly account for biological and hydraulic sensitivities.



ALBERTA ENVIRONMENT / ALBERTA FORESTRY LANDS & WILDLIFE
FISHERIES MITIGATION IN THE OLDMAN RIVER BASIN

2. Mitigation measures for the fishery, in upstream and downstream reaches of the basin, should take into consideration the availability of materials and equipment during the construction phase in order to achieve desired efficiencies in implementing the strategy.

3. Options to protect habitat and fish populations during the time of construction should be carefully examined and, where feasible, opportunities to maintain existing populations of fish should be used.

4. The implementation of the fisheries mitigation plan for the downstream area will need to be phased as development proceeds, as future studies are completed in order to define the various options available. These options will be better defined by studies and modelling presently underway.

In order to accomplish these recommended objectives, it is clear that a phased approach to planning, assessment, budgeting and construction should be taken. This would provide for a proper validation of the mitigation techniques to be employed. It is conceivable that this phased approach could require a decade to implement. The Mitigation Plan should strive to achieve flexibility in implementation as the base of data improves.

MAIN REPORT

1.0 INTRODUCTION

1.1 General

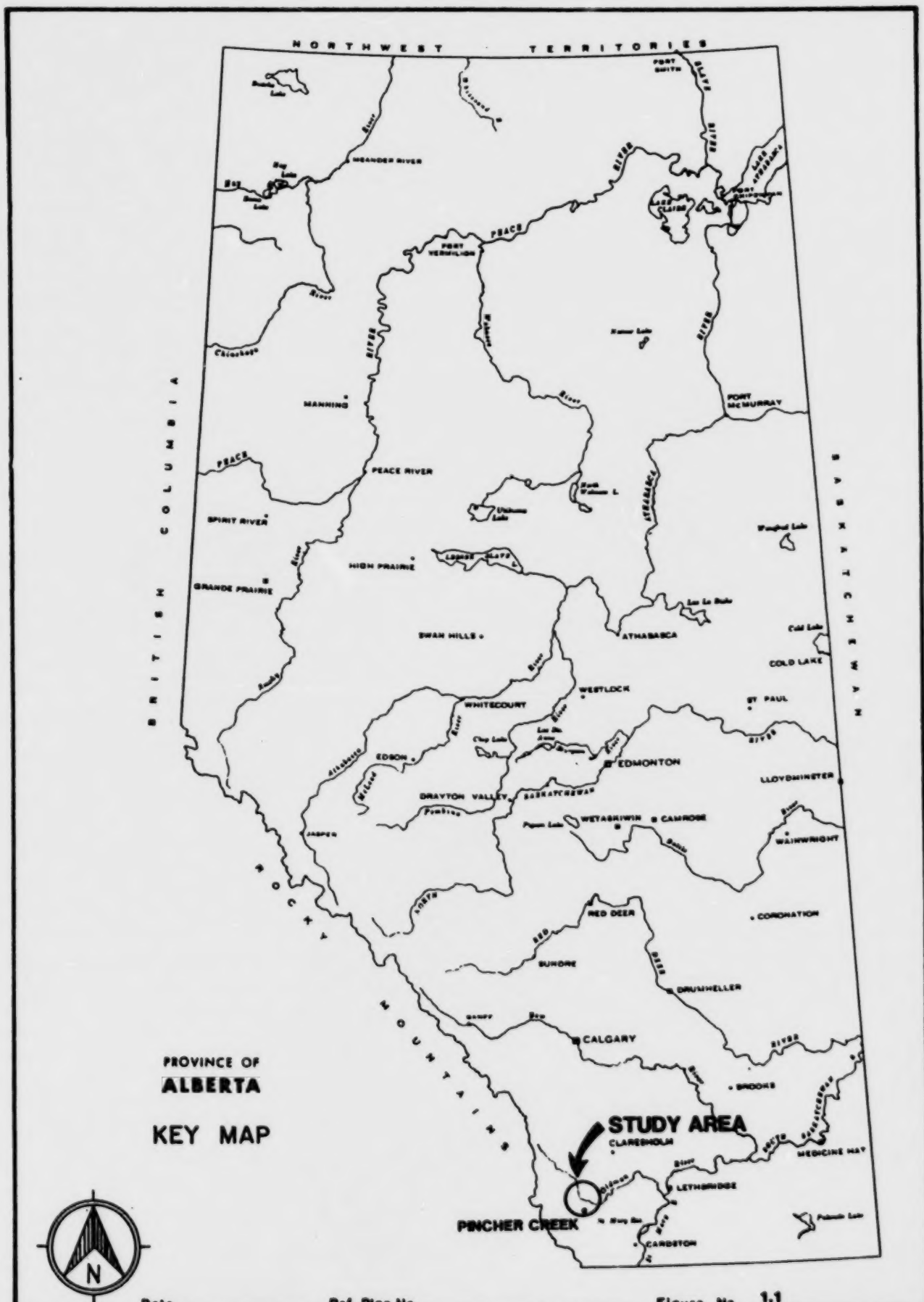
In August, 1984 the Government of Alberta announced that the Oldman River Dam would be constructed on the Oldman River northeast of Pincher Creek (Figure 1.1). In order that environmental concerns arising from the construction of the Oldman River Dam were addressed in a systematic and objective manner, the Planning Division of Alberta Environment developed a framework for studies that would lead to the formulation of an Environmental Mitigation/Opportunities Plan. With respect to the fisheries aspects of the environmental mitigation, several detailed studies on the fisheries resources upstream and downstream of the proposed dam have been undertaken and reported; (EMA, 1986, a,b,c; RL&L, 1986, a,b,c; Beak, 1986), these reports contain overviews and assessments of fish species, habitats, migrations and surveys of sports fishing activities.

The major objectives of the present study are as follows:

1) To compile and assess the variety of information pertinent to fishery mitigation from the reports supplied by Alberta Environment in the fields of fisheries, fisheries habitat, recreation, engineering and hydrology;

2) To consult with personnel of involved Provincial departments and the Local Advisory Committee of the Oldman Project and the Fish and Game Sub-Committee;

3) To identify, and screen for feasibility, potential mitigative options, both physical and biotic, as short and long-term components of a fisheries mitigation plan;



Date _____ Ref. Plan No. _____ Figure No. 1.1

Base Map by the Surveys Branch, Department of Highways and Transport, Edmonton, Alberta

4) To formulate a conceptual plan for stream habitat mitigation and to recommend selected habitat improvements to compensate for lost habitat. Conceptual engineering approaches were to be formulated for the habitat enhancement strategies identified.

5) To prepare estimates of the feasibility of mitigating losses of sports fishing for the Oldman River basin influenced by the dam.

The study has been carried out by Dominion Ecological Consulting Ltd., in association with JNMacKenzie Engineering Ltd. The project was commissioned by Alberta Environment on May 8, 1987, with a completion date of June 30, 1987. In order to facilitate proper consultation during the study, a tour of the study site and a meeting with the Local Fish and Wildlife Sub-Committee was held. Further, a detailed workshop with government staff was held on June 12, 1987 in order to discuss, and receive direction on, the key decisions and assumptions which led to the suggested strategy for fisheries mitigation.

The interim Fisheries Mitigation Strategy Report was presented to Alberta Environment on June 30, 1987. Since, that time, changes to the report have been made in response to comments and opinions of government agencies and the Local Advisory Committee. Also, the availability of further data from additional field studies recommended in the Interim Report has led to an update of certain crucial tabulations and conclusions and actual construction of fisheries mitigation structures has begun in the Intensive Study Area of the Crowsnest River.

1.2 Background

The Government of Alberta is in the process of constructing a water storage and flow regulation dam on the Oldman River at a site approximately 10 km northeast of Pincher Creek (Figure 1.1). At the full supply level (FSL) of elevation 1118.6 m the reservoir will have a volume of 490,000 dam^3 and a surface area of 2420 ha.

This study proceeded from a commitment of the Alberta Government, as specified in our terms of reference, to address losses of the existing fishery:

> "It is recognized that construction of the Oldman River Dam, to provide a flow regulation reservoir on the Oldman River, will alter the present habitat available to the fish populations of the area. The fishery in the area is considered to be a valuable resource and the objective of the fisheries mitigation plan will be to attain conditions of no net loss of recreational fishing opportunity as a result of dam construction."

Here, we proceeded in a series of steps each of which led to a better definition of possible mitigation strategies:

a) Quantification of riverine fishery habitat lost due to the construction of the dam and the filling of the reservoir.

b) An evaluation of habitat areas available for mitigation.

c) An overview of potential mitigation types which could be employed, along with a costing of such measures as required, in replacing lost fishery habitat.

Site-specific engineering approaches to habitat remediation are not feasible at this time due to insufficient site-specific information regarding habitat, particularly in upstream tributary reaches. However, it is our intent to provide a scoping study which will facilitate the final resolution of both the general approach and the specific methodologies eventually to be employed in the mitigation strategy to be implemented. Final cost estimates and engineering designs will be determined by the realities of riverine habitat and the physical availability of materials.

In providing a strategy for fisheries mitigation for the Oldman Dam Project, we have subdivided the Oldman River Basin into three zones. The reservoir zone is that portion of each of the three upstream tributaries (and all of the Oldman mainstem) that will be inundated. The Crowsnest River will lose 9.1 km to flooding, the Castle River 12.2 km, and the Oldman North Fork 6.4 km. The upstream zone above FSL will be impacted in that physical habitat mitigation techniques required to compensate for habitat losses in the reservoir will be undertaken here. This will result in a general upgrading of the assemblage of microhabitats. The downstream zone will be affected by a changed (more uniform) hydrologic regime, together with the potential for river bed degradation immediately below the dam. There will be a probable loss of important spawning habitat for mountain whitefish due to the dam acting as a barrier to upstream migration.

2.0 PURPOSE AND SCOPE OF STUDY

As touched upon above, the purpose of this study is to present a fisheries mitigation plan in terms of a series of options that if implemented would attain a condition of "no net loss of recreation fishing opportunity as a result of dam construction". The Terms of Reference for this study are presented as Appendix A. The definition of "no net loss of fishing opportunity" as used in this study, as well as the other conditions and constraints assumed in this study, are presented in the following section.

The mitigation strategy, as defined by Alberta Environment, is viewed in two phases. Phase 1 is the short term component comprising activities considered during the period from 1987 until the dam is scheduled to become operational in 1991. Phase 2 is viewed as a long term component of the mitigation strategy, and is expected to occur after the dam becomes operational in 1991. The intent of this strategy is to mitigate for fishery habitat lost due to inundation by the reservoir by providing equivalent fishery habitat above FSL.

The study addresses fishery mitigation in terms of three distinct geographic zones. Zone 1 is related to the area upstream of FSL. The strategy provides a plan that includes physical techniques to upgrade available low quality micro-habitats to more usable habitats; thereby compensating for high quality habitats lost to the reservoir on the three up-stream rivers. Zone 2 is restricted to the inundated area above the dam. Conceptual mitigative options are presented for the reservoir. Zone 3 involves the Oldman River down-stream of the dam. The final reservoir operating regime, consequent downstream flows, water temperatures and water - quality are not fully defined at this time. Work is ongoing to provide the data that will allow decisions to be made

with respect to mitigative options. Hence, it is difficult to formulate specific fishery mitigative options for this zone. As such, this section must deal broadly with those options that have the potential to solve likely problems arising from the construction and operation of the dam and reservoir.

Wherever it has been feasible, the options presented have been costed. The design and location of specific techniques or options have been given where possible. The eventual decision as to the degree of implementation of the mitigation strategy and funding available for implementation rests with the Alberta government.

Clearly, the scope of this study was determined by the available time and by the nature and degree of field studies which preceded it. The information contained in those previous studies commissioned by Alberta Environment, together with the assessments of fishery impacts of the Oldman River Dam done by staff of Alberta Environment, constituted the database upon which our study was based. In order to extend our information base on potential and available habitats for mitigation in upstream reaches of the Crowsnest, Castle and Oldman North Fork Rivers, a brief helicopter reconnaissance flight was undertaken on June 19, 1987. The information gleaned from this reconnaissance has been incorporated into the mitigation strategy along with a useful photographic record for future planning of specific in-stream mitigation projects. The survey also brought to our attention the importance of access in the implementation of physical techniques for mitigation. The decision of Alberta Environment to swiftly implement the recommendations contained in the June 30, Interim Report allowed an expansion of the database as it relates to general habitat avail-

ability above FSL. The extended surveys were undertaken in the summer/fall of 1987 and the data were incorporated into this final report.

3.0 ASSUMPTIONS AND CONSTRAINTS OF THE MITIGATION PLAN

In order to provide the range of mitigative options called for in the terms of reference, within the limited time period, several assumptions were made for this study. These assumptions and constraints were reviewed by Alberta Environment and Alberta Fish and Wildlife Division personnel at a workshop held in Edmonton June 12, 1987, and have been discussed in other informal meetings. The major assumptions of this study follow:

(1) "**No net loss of recreational fishing opportunity" is being defined as chiefly the replacement above FSL of the high quality fishery habitat lost to flooding below FSL but also including the mitigation of impacts on downstream fish populations.** This replacement will be by improvement of available lower quality (less than moderate to high quality) habitat to a high quality condition by a variety of techniques.

(2) **Riverine fishery habitat lost will be replaced by other riverine fishery habitat where possible (through mitigation) and not by a reservoir fishery.**

(3) **In order to evaluate the potential loss of fish due to the reservoir, the actual losses of high quality habitat will equate to fish lost.** It is understood that fish utilization of high quality habitat varies among the three main upstream tributaries (Crowsnest River has greater population of sports fish than other two rivers).

(4) **Wherever possible, the habitat to be replaced for each sport fish species and life stage will be implemented on sections of the same stream upstream of FSL as was lost below FSL.** Since available access and location

habitat for mitigation may be restricted, it will be necessary to propose mitigation on other upstream tributaries.

(5) **High quality fish habitat lost to flooding of the Oldman River mainstream is not wholly attributable to the Oldman North Fork for mitigation purposes.** It has been decided that apportionment of mitigation strategies will be most effectively focused on the Crowsnest River.

(6) **In order to carry out the physical enhancement techniques it will be necessary to upgrade habitat of a lower quality to higher grades.** However, this lower quality habitat can be, and is, utilized by some life stages of some species. Thus, inter-species trade-offs are necessary and the following species priorities were set out for the Study Team by Alberta Fish and Wildlife Division:

(a) **trout has priority over mountain whitefish on all three upstream rivers**

(b) **on the Crowsnest River brown trout has priority over rainbow trout (below Lundbreck Falls)**

(c) **habitat areas will be maintained, or enhanced, for selected riverine areas below the dam.**

Previous studies have evaluated enhancement projects in the Crowsnest Pass, and revealed that techniques used to improve and increase the habitat for trout rearing and adult holding had a concomitant increase in mountain whitefish populations of similar life stages.

(7) **The methodology employed has been to mitigate the maximum amount of lost habitat for the area in the surveyed data base.** It may be more appropriate to mitigate so as to maintain the optimum ratio of rearing to adult areas in the upstream section of each tributary above FSL. However, it is difficult to provide the specifics of this ratio, except that more rearing habitat is required than adult habitat to accommodate the usual population structure. Due to the overlap in the utilization of habitat by both the juvenile and adult lifestages, an optimal ratio of habitat will be maintained.

(8) **With respect to spawning areas lost below FSL, this study has used the data provided on specific spawning sites actually utilized, or strongly presumed to be utilized, rather than the mapped habitat area data on potential spawning areas.**

(9) **Overwintering sites lost below FSL were not mitigated for above FSL** since the impact assessments (RL & L, 1986c; Alberta Environment, 1987c) assume that the reservoir will provide overwintering habitat for the major sport fish species.

(10) **The mitigative options proposed for the reservoir and downstream of the reservoir are only conceptual at this time,** and firmer options will only be possible when the water regime water temperature and water quality of the reservoir and the resulting downstream flows are finalized.

(11) **Ultimate decisions on the proportional allocation of funding for mitigation between the geographic zones of the Oldman River Basin will be made by the Government of Alberta.**

4.0 CURRENT SPORT FISHERIES RESOURCE

4.1 Fish

Alberta Environment prepared a data summary from the various detailed fishery inventory studies carried out in the project area during 1985 and 1986 (Alberta Environment, 1987a), and the following data are taken from this report. Upstream of the dam site the fishery inventory focused on the Oldman River and its three main tributaries, the Crowsnest and Castle River and the Oldman North Fork (RL&L, 1986a;b). Prior to June 1987, the total length of stream studied above the dam site was 79 km, 43 km below FSL and 36 km above FSL, although detailed habitat mapping did not extend for all 36 km above FSL. The extension to the general habitat survey in the summer/fall of 1987 has expanded the limits of habitat areas upstream on all three main tributaries (see Figure 4.1). On the Crowsnest River the upper limit coincides with the Highway 3 crossing of the river, just below Crowsnest Lake. On the Oldman North Fork the upper data limit has been extended to the junction with the Livingstone River in the Livingstone Pass. The upper limit on the Castle River is at the junction of the Westcastle and Southcastle rivers to form the main stem Castle. Therefore, the summary of habitat availability has been expanded greatly, and while it is still not all inclusive of the area upstream of FSL, (excludes tributaries), it does now provide a reasonable idea of habitat available, and suitable for, mitigation purposes. Downstream from the dam site the study area for inventory purposes included the mainstem of the Oldman River to the confluence of the Little Bow River, a distance of 218.5 km. Inventory sampling was done on 6 representative segments (Figure 4.2) downstream of the dam.

The Oldman River Basin above the LNID weir, including the headwater streams of the Crowsnest, Castle and Oldman North

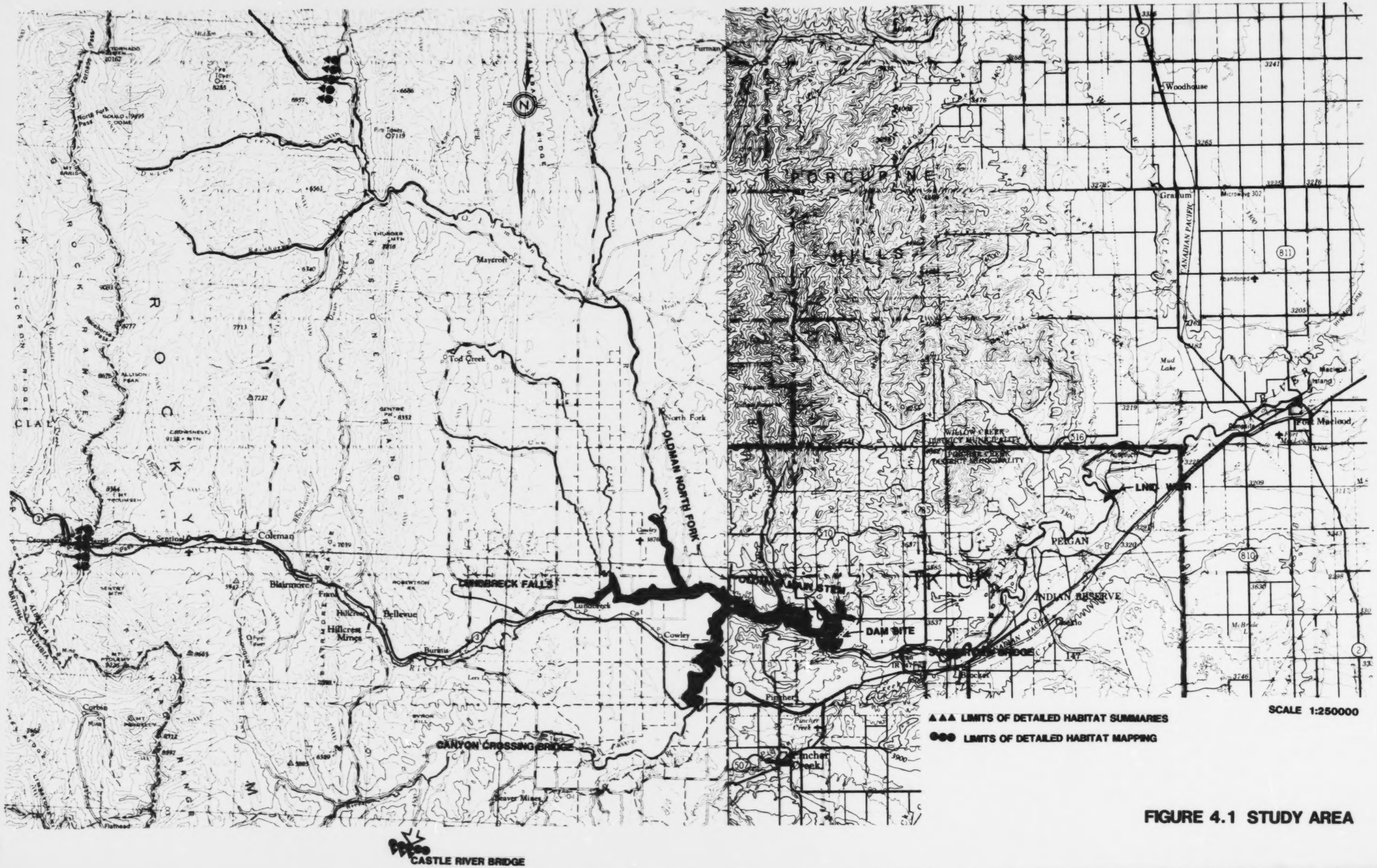
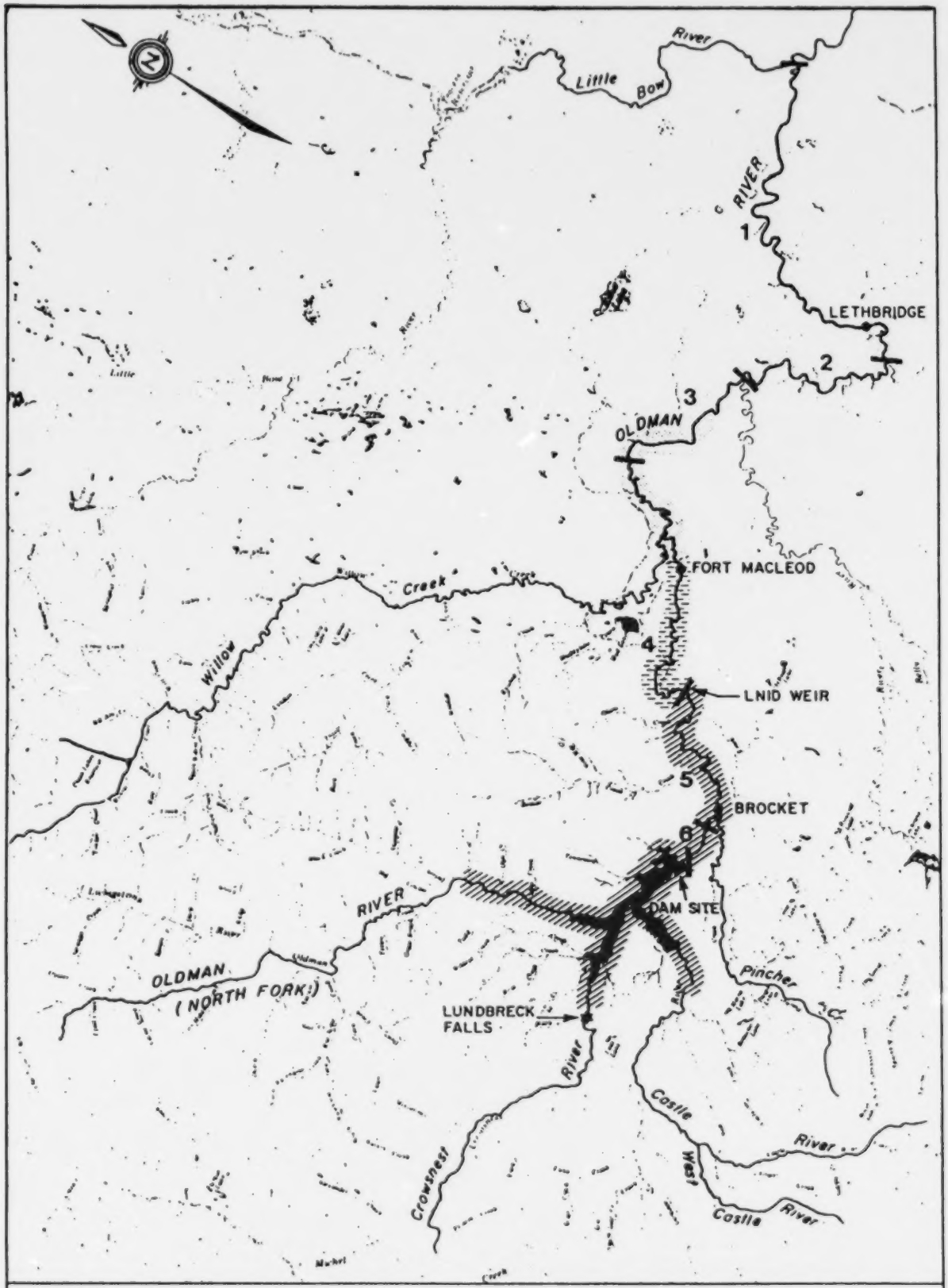


FIGURE 4.1 STUDY AREA



COLDWATER AND COOLWATER FISHERIES HABITAT ZONES

FIGURE 4.2

Fork, is classified as coldwater habitat (Figure 4.2). Below Fort Macleod, the Oldman River is classed as a coolwater habitat. A transitional zone, which has habitat for both coldwater and coolwater species, is found on the Oldman River between the LNID weir and Fort Macleod.

In the coldwater habitat zone, which is characterized by relatively cold and fast flowing water, the predominant sport fish species are rainbow trout and mountain whitefish. Other trout species, including brown trout, bull trout, and cutthroat trout, are present in small numbers, as are lake whitefish and burbot. In the coolwater habitat zone, the Oldman River has a decreased gradient and increased width, the flow is shallower and water temperatures are higher. The fish species found in this zone include walleye, sauger, northern pike, lake whitefish and mooneye. Mountain whitefish and lake whitefish are found in all three temperature zones because of their wide temperature tolerance.

4.1.1 Upstream of the Dam

Figure 4.1 shows the limit of the study reaches within which the RL&L fishery inventory surveys were undertaken.

Upstream of the dam, rainbow trout was the most widespread and numerous of the trout/char species inventoried by the surveys in all three tributary rivers (RL&L, 1986a). Rainbow trout were particularly abundant in the Crowsnest River, and generally showed better growth, and attained larger sizes, than in the Castle or Oldman North Fork Rivers. The Oldman North Fork River had a moderate rainbow trout population, but the Castle River exhibited low population levels.

Brown Trout were recorded in the Crowsnest River, below Lundbreck Falls, and the main stem Oldman River. The Crowsnest River supports a small but established brown trout

population. The few brown trout caught in the main stem Oldman River were assumed to be seasonal migrants from the Crowsnest River. No evidence of brown trout was found in the Castle River.

Mountain whitefish were the most abundant sportfish in all of the upstream study streams, comprising more than 80% of all sportfish captured. Population densities were highest in the Crowsnest, followed by the Oldman River and Castle River. Again, size and growth rates were higher for the Crowsnest than the other two streams.

Bull trout were recorded in each of the three streams, but mainly in the Castle River. The distribution of bull trout was sporadic and the fish mainly immature. Only one cutthroat trout was recorded, and this in the Crowsnest River.

It appears that the stream reaches above the dam site are currently able to meet all the life history requirements of local trout populations, and it is quite possible that at least a portion of the trout populations are year-round residents (Beak, 1986). The Crowsnest River below Lundbreck Falls was more important to spawning rainbow trout than the other stream sections. The significantly greater densities of rainbow trout and mountain whitefish in the Crowsnest River compared to the Castle River (and the Oldman North Fork) is probably related to differences in general salmonid habitat quality. However, the effect of Lundbreck Falls as a barrier to upstream migration might be a contributing factor in the increased downstream fish densities (Beak, 1986).

4.1.2 Downstream of the Dam

Downstream of the dam site sport fish distribution is related to the distribution of coldwater habitat, i.e. the three stream study segments (Figure 4.2) closest to the dam (EMA, 1986 a,b). The trout species were found in the cold-water segments, and were virtually absent from the transition zone habitats. Mountain whitefish were the most frequently observed and widely distributed sport species downstream of the dam site. They were found in all study segments of the Oldman River, except for the lowest one downstream of Lethbridge. The mountain whitefish population density decreased in a downstream direction. Sauger and walleye were captured occasionally downstream of Fort MacLeod, but were absent above. Other coolwater species were captured during inventory surveys, including lake whitefish (adults migrating up from downstream rivers or reservoirs), northern pike (found downstream of Brocket, and appear to use the Oldman River for feeding, spawning and overwintering), and burbot. Mooneye were rare, but a few adults were captured below Fort MacLeod possibly while migrating up into the Oldman River from the South Saskatchewan for summer feeding.

4.1.3 Non-Sport Fish

In addition to the sport fish summarized above there are several species of coarse or forage fish presently encountered in the Oldman River system that could become significant upon completion of the dam and filling of the reservoir. It is expected that the fish fauna of the Oldman Reservoir will be dominated by longnose and white suckers, and that several forage species (longnose dace, lake chub, trout perch and spoonhead sculpin) could be successful in the reservoir (EMA, 1986, a,b).

4.2 Sport Fishing

The degree of utilization for sport fishing in any stream is a result of the combination of the intrinsic (or perceived) quality and type of fishery, and the degree and ease of access to that resource. Upstream of the dam site there is a very distinct pattern of utilization of each of the three main streams. From fishing surveys in late 1985 (RL&L, 1986 a, and updated in Alberta Environment, 1987c) it appears that approximately 75% of the angling effort on the Oldman River system above the dam site was expended on the Crowsnest River. The Oldman and Castle Rivers showed values of 11% and 14%, respectively, in the same survey.

Approximately 68% of the total angling effort in this upstream area occurred above the area that will be inundated by the Oldman Dam reservoir at full supply level (FSL). For the Crowsnest River, in particular, 78% of the angling effort was above FSL. The section of the Crowsnest River near the Lundbreck Falls Recreation Area is a very significant sport fish site (representing 52% of the total angling effort for the study reach of the Crowsnest River). This is a good example of the importance of access in determining the degree of utilization of a stream for angling. On the Oldman River angling effort was light both above and below FSL. Approximately 72% of angling effort on the Castle River was above FSL, with 58% of the total angling effort expended at one site (Canyon Bridge crossing, Figure 4.1) with good access.

Mountain whitefish were the most frequently caught species at every creel survey site except on the Crowsnest River, where rainbow trout were the most common catch (Alberta Environment, 1987c). The highest catch rates, as represented by Catch Per Unit Effort, (CPUE) were for mountain whitefish in the Oldman and Castle Rivers, higher

than for any species on the Crowsnest. However, the highest catch rates for rainbow trout were from the Crowsnest. Thus, in the upstream rivers above the dam site, the Crowsnest River was the most popular river for angling,probably due partly to its high trout catch rates (quality/type of fishery).

The fishing survey of 1985 (Alberta Environment, 1987c) included one site on the Oldman River downstream of the dam site. This was the Summerview Bridge site (Figure 4.1) which is a popular site among local fisherman, mainly for mountain whitefish (96% of catch). Once again this emphasizes the importance of access in determining the degree of usage and popularity of a site for angling. Further, anglers can have easy access to the river because of the nature of the streambank.

4.3 Existing Fisheries Habitat

4.3.1 Habitat Classification

This section of our report presents the existing, pre-Oldman Dam construction, fisheries habitat. In order to quantify this presentation, we introduce here a physical habitat classification system which defines specific habitat in the Oldman River System in physical, qualitative and quantitative terms (RL&L,1986a). This classification system was developed and used by RL&L in the mapping program, and is the basis of much of the discussion about fishery habitat in the inventory reports. Hence, their classification system was the appropriate one for use in this study. Upgrading of poorly utilized or poor quality habitat by physical techniques was considered to be the most likely methodology for fishery mitigation. The classification system has been used in Alberta on previous occasions, and Alberta Fish and Wildlife Division has provided review input (RL&L, 1986a) to

ensure that local habitat differences are reflected.

The habitat classification involves measures of water depth and velocity, and substrate type, and is presented in two major sub-classifications. The first of these applies to reaches of the river system with definitive gradients (slopes) which produce rapid to very rapidly flowing water. The second sub-classification applies to reaches of the river system with very low, or no gradients (slope), which produce areas of still or very near to still water.

4.3.1.1 Definitive Gradient River Reaches

The following definition of physical habitat have been adopted from that given in RL&L (1986a, Appendix B1).

Rapids (RA)

This classification applies to river reaches with the highest velocity relative to other habitat types. The substrate in these reaches is extremely coarse, dominated by large cobbles and boulder materials.

RA/CH

Rapids associated with a defined chute.

Riffle (RF)

This classification applies to a river reach with generally a lower flow velocity than found in rapids. The water surface in this classification will be broken due to the effects of submerged or, in cases, exposed bed material. Riffles are relatively shallow (less than 50 cm) during moderate to low flow periods. There are two sub classifications applied to the riffle classification:

- Riffle (RF).

This classification applies to the above described riffle habitat with limited submerged or overhead cover for juvenile and adult life stage fishes. It has a coarse substrate, with very little in-channel large boulders.

- Riffle/Boulder Garden (RF/BG)

This classification occurs in a riffle habitat with a significant occurrence of large boulders in the stream. The significance of these boulders is that they provide instream cover for juvenile, and to some degree adult fishes, for moderate to high flow events.

Run (R)

This classification applies to a river reach which has moderate to high flow velocities, but less than rapids. The main physical difference in appearance of this classification and riffles is that the water surface of a run is largely unbroken by either submerged boulders and/or cobbles, or exposed bedrock material. This classification is deeper than a riffle habitat type. It may be differentiated into four sub-types: deep slow, deep fast, shallow slow, and shallow fast. In addition there are several further sub-classifications developed on the basis of habitat quality:

- Run Class 1 (R1)

This is the highest quality run habitat classification. It generally has a maximum water depth exceeding 1.5 metres with an average depth of 1.25 metres or greater. There is high instream cover for fish for all flow conditions. This cover is generally provided by submerged

boulders, fractured bedrock, or simply the depth of the water involved.

- R1/BG

  R1 associated with boulder garden.

- Run Class 2 (R2)

  This is a moderate quality run habitat type. Maximum depth of this classification may reach 1.0 metres but is generally somewhere in the order of 0.75 metres. There is high instream cover, again provided by submerged boulders, bedrock fractures, or depth, for all but low flow events occurring late in the summer and fall period.

- Run Class 2/Boulder Garden (R2/BG)

  Again this is a moderate quality run habitat. The boulder garden classification implies the presence of large boulders in the channel. These provide high instream cover at all but low flow events occurring late in the summer and early fall. The depth characteristics of this classification are similar to class 2 without the boulder garden, but may be lower in depth due to the cover provided by the boulders.

- Run Class 3 (R3)

  This is the lowest quality run habitat classified. The maximum depth of flow may reach 0.75 metres but generally is in the order of 0.5 metres. There is very little instream cover for all but the highest flow events, occurring early in the spring and early summer periods.

- Run Class 3/Boulder Garden (R3/BG)

  This classification is similar to an R3 classification in velocity and depth characteristics. However the presence of large boulders in the channel offers improved instream habitat during moderate and high flow events.

4.3.1.2 Low, or no Gradient River Reaches

Flats

Area of channel characterized by low current velocities (relative to riffle and run habitat types); near laminar (i.e. non-turbulent) flow character. Depositional area featuring predominantly sand/silt substrates. Differentiated from pool habitat type on basis of high channel uniformity and lack of direct riffle/run association. More depositional in nature than R3 habitat.

Pool

The pool classification applies to a specific, identifiable portion of an overall river reach, which features increased depth and reduced velocity relative to run and rapid habitat types. It may be thought of, in many respects, as a small instream lake. There are several sub classifications:

- Pool Class 1 (P1)

  This is the highest quality pool habitat classified. This classification may have a maximum depth exceeding 1.5 metres, however, an average depth is generally in the order of 1.25 metres. There is high instream cover at all flow conditions provided by submerged boulders, bedrock fractures, the actual depth of the water involved, or

bank irregularities and overhangs.

- Pool Class 2 (P2)

This is moderate quality pool habitat type. The maximum depth of water in this classification may reach or exceed 1.0 metres, but generally is in the order of 0.75 metres. There is generally high instream cover, again provided by boulders, bedrock fractures, and bank irregularities, for all but low flow events occurring in the late summer and early fall period.

- Pool Class 3 (P3)

This is the lowest quality pool habitat classification, where the maximum depth may reach 0.75 metres but generally averages in the order of 0.5 metres. There is low in-stream cover for any but high (spring/early summer) flow periods.

In addition to the above noted classifications, other in-stream habitat features are found.

Chutes (CH)

This classification applies to areas of channel constriction which result in a deeper channel with increased velocity. It is generally associated with habitat classifications RA, R1, or R2.

Ledges (LG)

This classification applies to areas where there is a bedrock intrusion into the channel. The intrusion will often create chutes and/or pool habitat.

4.3.2 Existing Physical Habitat

An earlier study (RL&L,1986a) undertook a detailed survey of riverine fisheries habitat in the Oldman River system, using the habitat classification system described in the previous section. The survey was only mapped on a site specific basis from the dam site to the reservoir FSL, with the exception of the Crowsnest River assessment which extends to Lundbreck Falls (Figure 4.1). The habitat database is, therefore, definitive with respect to the type and amount of habitat which will be lost due to inundation by the reservoir.

After further survey work in the summer/fall of 1987, generalized data on habitat type and availability are now available for a large portion of the main tributaries of the upper Oldman River Basin. The limits of this survey are shown on Figure 4.1. The fisheries habitat for each of the Castle, Crowsnest, Oldman North Fork and Oldman Main Stem River, based on the above database, as adapted from RL&L (in press) is presented in Table 4.1 to Table 4.4.

TABLE 4.1

EXISTING FISHERIES HABITAT - CASTLE RIVER

HABITAT TYPE	ABOVE FSL (sm)	BELOW FSL (sm)	COMBINED (sm)
RF	143,094	27125	170,219
RF/BG	170,747	0	170,747
RA	174,783	122764	297,547
RA/BG	89,323	30263	119,586
RA/CH	4,830	0	4,830
RA/RF	0	8900	8900
R1	32,288	66063	98,351
R1/BG	0	0	0
R2	171,164	86513	257,677
R2/BG	11,989	12600	24,589
R3	425,664	33300	458,964
R3/BG	155,935	1600	157,535
TOTAL	1,379,817	389128	1,768,945

HABITAT TYPE	ABOVE FSL (number)	BELOW FSL (number)	COMBINED (number)
P1	24	5	29
P2	54	6	60
P3	56	0	56
CH	18	14	32
LG	76	3	79
FL	0	0	0

TABLE 4.2

EXISTING FISHERIES HABITAT - CROWSNEST RIVER

HABITAT TYPE	ABOVE FSL (sm)	BELOW FSL (sm)	COMBINED (sm)
RF	191,458	55830	247,288
RF/BG	67,069	8910	75,979
RA	28,246	16680	44,926
RA/BG	68,255	8148	76,403
RA/CH	716	0	716
RA/RF	0	0	0
R1	21,584	18075	39,659
R1/BG	0	0	0
R2	105,538	17935	123,473
R2/BG	21,011	2875	23,886
R3	307,298	88790	396,088
R3/BG	61,305	1705	63,010
TOTAL	872,480	218948	1,091,428

HABITAT TYPE	ABOVE FSL (number)	BELOW FSL (number)	COMBINED (number)
P1	29	3	32
P2	105	3	108
P3	134	0	134
CH	13	6	19
LG	43	4	47
FL	5	0	5

TABLE 4.3

EXISTING FISHERIES HABITAT - OLDMAN RIVER NORTH FORK

HABITAT TYPE	ABOVE FSL (sm)	BELOW FSL (sm)	COMBINED (sm)
RF	183,134	56663	239,797
RF/BG	294,257	0	294,257
RA	61,302	32275	93,577
RA/BG	116,780	9225	126,005
RA/CH	7,927	0	7,927
RA/RF	0	6750	6,750
R1	36,197	34450	70,647
R1/BG	326	0	326
R2	105,186	27500	132,686
R2/BG	34,797	5850	40,647
R3	478,504	7863	486,367
R3/BG	221,218	0	221,218
TOTAL	1,539,628	180576	1,720,204

HABITAT TYPE	ABOVE FSL (number)	BELOW FSL (number)	COMBINED (number)
P1	27	2	29
P2	72	2	74
P3	94	1	95
CH	22	6	28
LG	147	2	149
FL	1	0	1

TABLE 4.4

EXISTING FISHERIES HABITAT - OLDMAN RIVER MAIN STEM

HABITAT TYPE	ABOVE FSL (sm)	BELOW FSL (sm)	COMBINED (sm)
RF	0	46738	46738
RF/BG	0	0	0
RA	0	138188	138188
RA/BG	0	25963	25963
RA/CH	0	0	0
RA/RF	0	18700	18700
R1	0	84763	84763
R1/BG	0	0	0
R2	0	239113	239113
R2/BG	0	0	0
R3	0	85050	85050
R3/BG	0	0	0
TOTAL	0	638515	638515

HABITAT TYPE	ABOVE FSL (number)	BELOW FSL (number)	COMBINED (number)
P1	0	0	0
P2	0	10	10
P3	0	3	3
CH	0	7	7
LG	0	6	6
FL	0	0	0

4.4 Habitat Utilization

Previous analyses (RL&L, 1986a) have determined habitat utilization relationships for the dominant fish species in the Oldman River system (Table 4.5). The use ratings are as follows:

5 high
4 moderately high
3 moderate
2 low - moderate
1 low
0 nil - low

The assessment was based on the distribution of fish in August, September, and October (by electrofishing), with the exception of overwintering use based solely on October electrofishing and depth measurements.

Earlier analyses (RL&L, 1986a) also concluded that only habitat use ratings of 4 and 5 are critically important to the fish species involved. This implies that habitat with a use rating below 4 may be thought to have little value, and would thus be available for modification (in terms of mitigation works) at little or no penalty to the pre-mitigation fish utilization. A summary of the types of habitat that are considered as valuable, in terms of utilization (use ratings of 4 or 5) in the Oldman River basin, is presented in Table 4.6.

TABLE 4.5
RELATIVE USE OF HABITAT TYPES

LIFE STAGE	SPECIES	USE RATING												
		RF	RF/BG	RA	RA/BG	RA/RF	R1	R2	R2/BG	R3	R3/BG	P1	P2	P3
SPAWNING	BNT	5	5	0	0	1	0	2	0	5	5	0	0	0
	MW	3	2	1	1	2	0	5	4	1	1	0	0	0
	RT	PREFER	-	-	-	-	-	-	-	PREFER	-	-	-	-
JUVENILE	BNT	1	2	2	5	1	4	3	4	2	2	2	3	2
	MW	4	5	2	3	3	1	3	3	4	4	1	2	2
	RT	4	5	3	4	3	2	2	3	2	3	2	2	2
ADULT	BNT	1	1	1	2	1	5	3	4	1	1	5	3	1
	MW	1	2	4	5	3	4	4	5	1	2	4	3	2
	RT	1	1	2	3	2	5	3	4	1	1	5	3	1
OVERWINTERING	BNT	0	0	1	1	1	5	4	4	0	0	5	2	1
	MW	0	0	2	2	1	5	4	4	0	0	5	2	1
	RT	0	0	1	1	1	5	4	4	0	0	5	2	1

SOURCE RL&L (1986,a,b)
USE RATING: 5(HIGH), 4(MODERATE TO HIGH), 3(MODERATE), 2(LOW TO MODERATE), 1(LOW), 0(NIL TO LOW)

TABLE 4.6

HABITAT USE SUMMARY BY SPECIES AND LIFE CYCLE(1)

SPECIES	LIFE CYCLE	HABITAT TYPE (CLASSES 5& 4)
BROWN TROUT	SPAWNING	RF, RF/BG, R3, R3/BG
	REARING	RA/BG, R1, R2/BG
	ADULT FEEDING	R1, P1, R2/BG
	OVERWINTERING	R1, P1, R2/BG, R2
RAINBOW TROUT	SPAWNING	RF, R3
	REARING	RF/BG, RF, RA/BG
	ADULT FEEDING	R1, P1, R2/BG
	OVERWINTERING	R1, P1, R2, R2/BG
MOUNTAIN WHITEFISH	SPAWNING	R2, R2/BG
	REARING	RF/BG, RF, R3, R3/BG
	ADULT FEEDING	RA/BG, R2/BG, RA, R1, P1, R2
	OVERWINTERING	R1, P1, R2, R2/BG

NOTE (1) summary of data adapted from RL&L (1986a)

5.0 OLDMAN RIVER DAM IMPACTS

5.1 Oldman River Dam

The Government of Alberta announced in August of 1984 that a dam would be constructed on the Oldman River northeast of Pincher Creek. The Oldman River Dam is to provide flow regulation and on stream storage to yield a dependable supply of water to permit multi-purpose use and irrigation expansion in southern Alberta.

The dam has a full supply level (FSL) of 1,118.6 metres (GSC), with a reservoir live storage, at FSL, of 490,000 dam^3. The surface area of the reservoir, at FSL, is 2,420 hectares. The dam will have a maximum height of 76 metres and a crest length of 3,070 metres.

The catchment area of the Oldman River Dam is 4400 km^2 and lies between the Continental Divide and the Porcupine Hills. Approximately half of the catchment drains to the upper Oldman River; the remainder of the catchment is divided approximately equally between the Crowsnest and Castle Rivers.

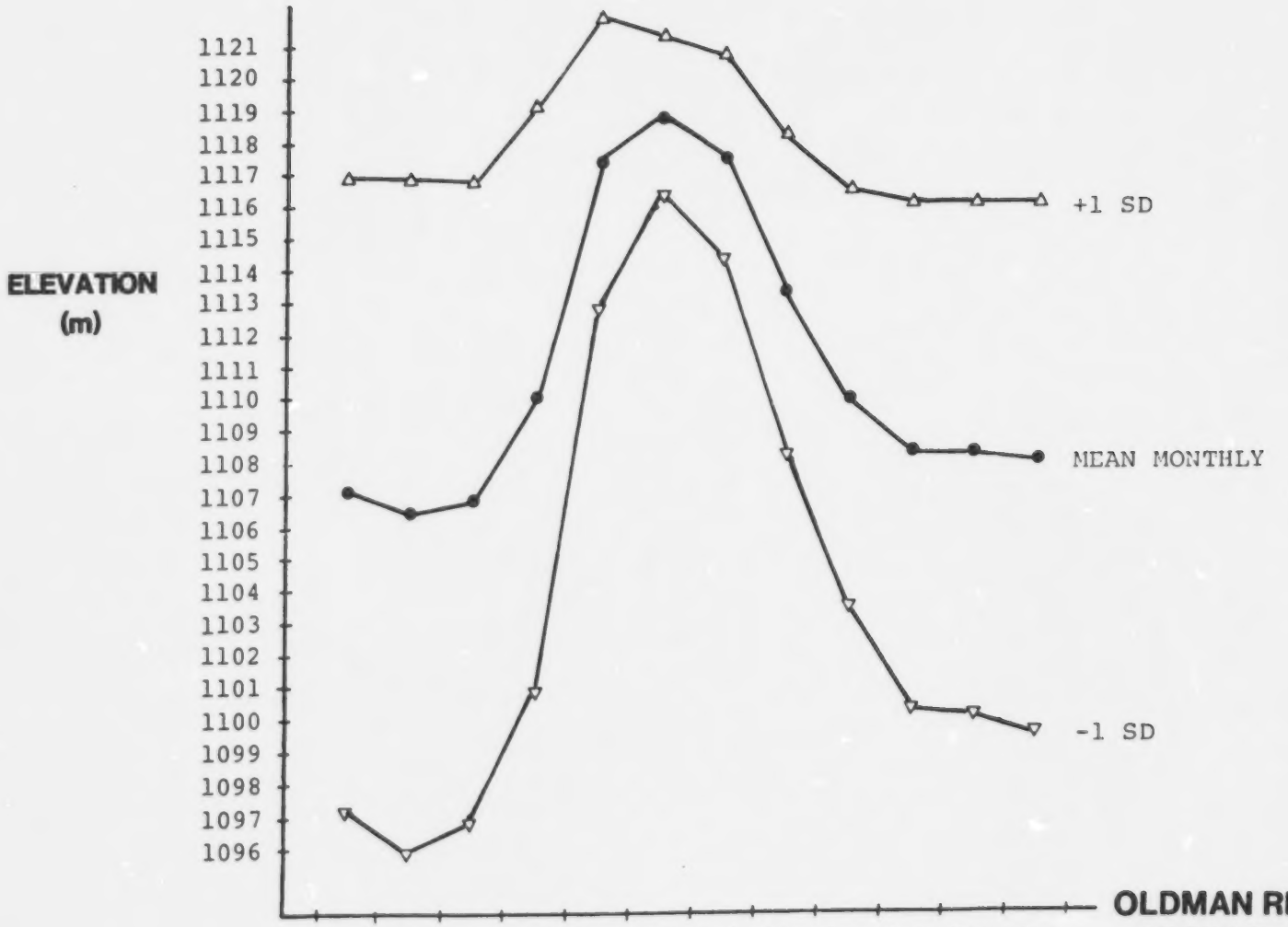
The reservoir will consist of a narrow 15 km long lower reach adjoined by three arms formed by the Oldman North Fork, Crowsnest and Castle Rivers (UMA, 1986). It is expected that the reservoir operating regime will be hypolimnetic (i.e. bottom discharge), and will be adjusted to meet the seasonal demands for irrigation water. Reservoir water levels will rise during spring flood (April, May and June), decline during the irrigation season (July to October) and remain relatively stable during winter (November to March). At full irrigation development the drawdown from June reservoir levels to October level could be 10 m (based on data provided in June, 1987, by Planning

Division, Alberta Environment), (Figure 5.1).

5.2 Mitigation Philosophy

In the terms of reference, the mitigation plan was considered in two phases, short term and long term. Phase 1 (short term) is to include mitigative options that can or should occur during the construction of the dam (1987 to 1991), while Phase 2 will have options that may be implemented after closure of the dam. Mitigation works have been addressed herein for three distinct areas with respect to the project: upstream of the dam; the reservoir itself; and downstream of the dam.

In discussions with members of the Oldman Project Sub-Committee on Fish and Wildlife, and regional Fish and Wildlife personnel, it became apparent that preferences for mitigative options were upstream, downstream and reservoir in order of priority. The upstream riverine enhancements were considered the highest priority, and many felt that all habitat and sport fish losses due to the dam should be recovered here. Accordingly, the present study has focused mainly upon this zone, providing engineering details and costs where appropriate. The second priority would be for mitigation downstream of the dam although it is also felt that the beneficial effects for fish populations of a higher minimum flows under regulation could be sufficient. Also, because the degree and type of mitigation implemented will depend greatly upon decisions of government, and results of water temperature models and other studies now ongoing, the present study has not treated this zone with the same degree of detail as found for the upstream zone. There was little local support for a reservoir fishery to compensate for lost riverine fish and habitat.



OLDMAN RIVER RESERVOIR
OPERATING LEVEL DATA
Based On Full Irrigation Development

FIGURE 5.1

5.2.1 Upstream of FSL

This area includes the Castle, Crowsnest and Oldman North Fork Rivers above reservoir full supply level. Mitigative techniques will be applied in these areas to compensate for the losses of high quality habitat in the flooded zone. Although habitat data have only been provided for the Crowsnest, Castle and Oldman North Fork Rivers, mitigation should also be considered for all suitable tributaries to these rivers, especially the Crowsnest River.

In the inventory and habitat surveys done for Alberta Environment, detailed habitat maps were only provided for the Crowsnest River up to Lundbreck Falls, and a few kilometers upstream of FSL on both the Castle and Oldman North Fork (Figure 4.1). Physical stream mitigation is proposed beyond the reach of the detailed habitat mapping on the Crowsnest, Castle and Oldman North Fork Rivers, in the zones covered by the general habitat survey summaries, and beyond the survey area in the headwater tributaries. Constraints imposed by access limitations (for construction and future angling purposes) will limit mitigation projects to discrete sites.

5.2.2 The Reservoir

At this stage of the project, temperature and water quality aspects have been taken from preliminary studies (HydroQual, 1985). While that report was not based upon the most recent operational data for the Oldman reservoir release rates, the general conclusions on reservoir water temperature, stratification and water quality probably reflect conditions which will be found after construction. The data on water level drawdown within the reservoir were made available from Alberta Environment Planning Division (D.Hagerman, personal communication June 9, 1987). These preliminary data allow only a general assessment of the effect of the projected

range of water level changes as they might affect the littoral zone and subsequently fish habitat.

Nevertheless, given these constraints it is clear that there will be limited options for fisheries mitigation in the reservoir, and our discussion reflects these limitations.

5.2.3 Downstream of the Dam

Some mitigative options might fall into Phase 1, which includes spawning channels. These could be built during the period of dam construction, in order to utilize available equipment and techniques, especially in the tailwater zone close to the dam. Other mitigative options fall under Phase 2, in that further modelling is required to provide the water temperature, quality and flow regimes which will determine the availability of suitable habitat. Studies are being undertaken to provide data that will aid the selection of options.

5.3 Impacts

5.3.1 Approach

EMA (1987), RL&L (1986c) and Alberta Environment (1987c) constitute preliminary or draft assessments of the impact on fisheries predicted from the Oldman River Dam. Our study took as its starting point these assessments of specific fishery habitat losses in the reservoir and downstream. The mitigative options proposed for lost fishery habitat are predicated upon these assessments.

Our approach to the evaluation and quantifications of fishery habitat losses were pragmatic in response to limited

availability of detailed site-specific habitat mapping upstream of the FSL. The approach used employed the assessment data as presented for fish habitat loss by life stage and species. These data were converted to habitat classification units which have general hydrologic and substrate characteristics that, in turn, may be upgraded by physical mitigation techniques.

5.3.2 Upstream of FSL

Upstream of the full supply level of the dam there will be no physical impacts due to the construction of the Oldman River Dam. There will, however, be a major impact in terms of the prevention of migration of fish upstream or downstream through the dam site.

5.3.3 The Reservoir

5.3.3.1 Reservoir Sedimentation

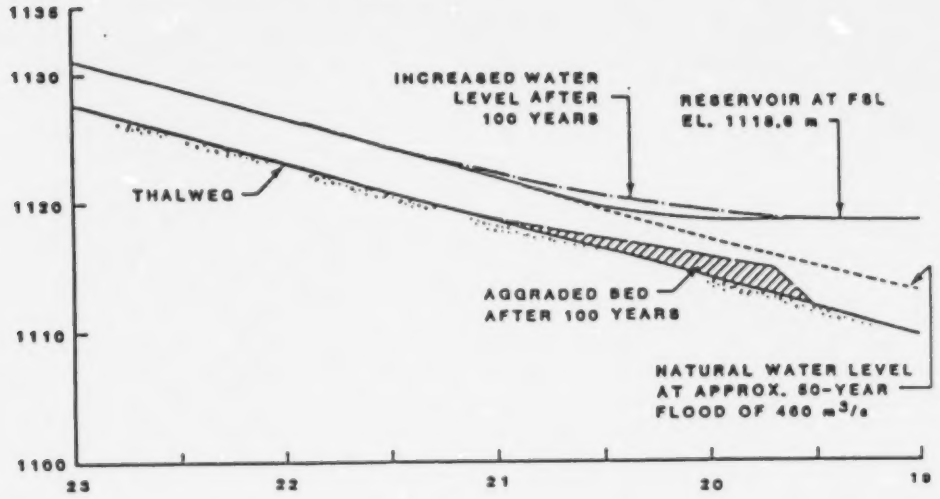
Northwest Hydraulic Consultants Ltd. (NHCL, 1987) have completed an analysis of the river morphology and sedimentation effects of the Oldman River Dam. This section of the current report draws fom the NHCL report.

At the upstream end of the reservoir, in the backwater zone where the river merges into the reservoir, deposition of bed load will form a delta. In time, these increases in bed levels will result in further increases in water levels.

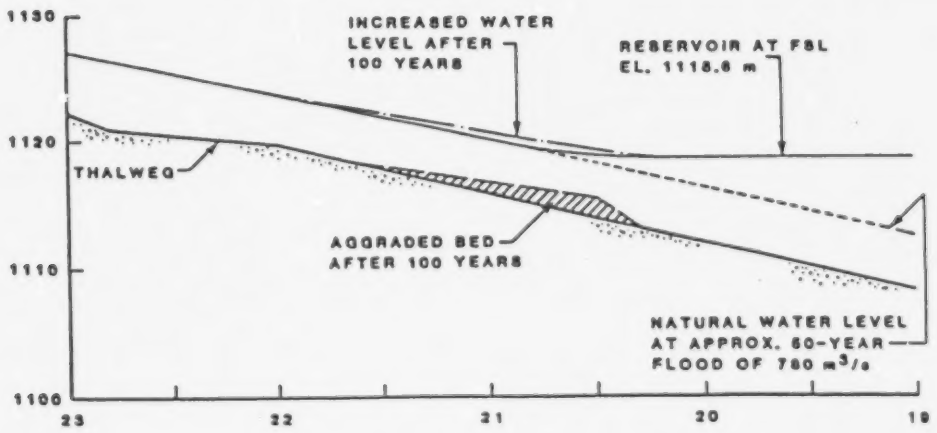
Of the three river channels at the head of the Oldman Reservoir, aggradation will only occur in the Upper Oldman and Castle rivers, as bed load transport in the Crowsnest River is negligible.

Figure 5.2 is a diagrammatic representation of the projected

UPPER OLDMAN RIVER



CASTLE RIVER



GEODETIC ELEVATION, m

DISTANCE UPSTREAM OF DAM, km.

NOTES:

- NELIGIBLE AGGRADATION EXPECTED IN THE CROWSNEST RIVER.
- ASSESSMENT IS BASED ON RESERVOIR HELD AT FULL SUPPLY LEVEL.

SOURCE (NHCL,1987)

AGGRADATION AT HEAD OF RESERVOIR

FIGURE 5.2

aggradation in the upper Oldman and Castle rivers after 100 years (NHCL, 1987). In the upper Oldman River, bed levels will increase by a maximum of 2 m. This will cause water levels to increase by a maximum of 1 m at extreme flood flows. Increases in water levels will be negligible within a few kilometres of the head of the reservoir. On the Castle River the bed level will increase by a maximum of approximately 1.7 m. Water levels will increase by a maximum of 1 m, but will be negligible within a few kilometres of the head of the reservoir.

The above assessment is based on the reservoir being held at approximately full supply level. Reservoir operation that results in the level fluctuating of a few metres for example would cause the aggradation to be spread over a greater length of channel thereby reducing the projected increases in bed and water levels.

The major concern touched upon by the current analysis is whether or not fish will be able to migrate, during fall low flow periods, through the zone of aggradation on the Oldman North Fork, and Castle Rivers. Analyses to date on this matter are not definitive; However, we consider it most likely that channels will be maintained to allow for fish migration to the reservoir area for overwintering habitat. We have assumed in our analysis that the fish will move to the reservoir, however, further monitoring will be required in this respect.

5.3.3.2 Water Quality and Water Temperature

The reservoir will thermally stratify during summer months (HydroQual, 1985). Stratification will likely not occur before July, and will break down anywhere from early September to early October. Timing of fall mixing of waters is sensitive to the reservoir operating regime and upstream

river flow conditions. Due to its greater depth and volume the Oldman Reservoir will be cooler than other onstream reservoirs in the area (St. Mary and Dickson Reservoirs).

During fall, variation in reservoir cooling, reservoir release rates and atmospheric temperature conditions all combine to cause considerable variability in downstream river temperatures. It will be possible to make better river temperature projections when the reservoir operating regime is more clearly defined.

Assuming winter flows downstream of the dam range from 5 to 15 m^3/sec, the ice free reach in the Oldman River will vary between 8 and 53 km depending upon weather conditions.

Projected nutrient loadings and resultant chlorophyll levels indicated the reservoir will be relatively unproductive for planktonic algae. It will fall within the upper oligotrophic to lower mesotrophic range of trophic state. Fluctuating water levels will limit the near shore biological community of aquatic plants and benthic invertebrates (HydroQual, 1985).

If the reservoir area is cleared of vegetation before filling, the trophic upsurge experienced immediately after reservoir filling will likely be minimal, and restricted to the first one or two years. During trophic upsurge the reservoir should stay within the mesotrophic range.

Following trophic upsurge, summer hypolimnetic oxygen depletion in the reservoir will be minimal, therefore release of deoxygenated waters to the downstream Oldman River should not occur. Winter oxygen depletion will also be minimal. In the first few years after filling the summer bottom water oxygen levels will be reduced relative to the

long term condition. HydroQual(1985) strongly recommended that the vegetation be stripped from the site to reduce the oxygen demand if bottom withdrawal is selected.

5.3.3.3 Loss of Fisheries Habitat

As discussed in the assumption and constraints section of this report, the mitigation plan does not address spawning or overwintering habitat in detail.

The amount of spawning habitat lost due to inundation is difficult to determine. The preferred spawning habitat occurs extensively throughout the study reaches (RL&L, 1986a). Brown trout utilize RF, RF/BG, R3 and R3/BG. Mountain whitefish utilize reaches with faster flowing water and coarser substrate, such as the R2 and R2/BG. Rainbow trout utilize some of habitat used by the brown trout (RL&L, 1986b), specifically RF and R3. The areas of the actual spawning sites are relatively small, in terms of the area of its overall habitat type. The spawning sites (RL&L, 1986a,b) in the surveyed reaches for both total and below FSL are shown in Table 5.1. Further studies on spawning and spawning sites are being considered at the time of writing.

No loss of confirmed brown trout spawning areas will occur. The loss of confirmed rainbow trout spawning is restricted to one site on the Crowsnest with further loss of four unconfirmed sites of the Castle and Oldman North Fork Rivers. The loss of spawning for trout is considered to be minimal. The loss of mountain whitefish spawning is not considered to be significant considering that the specific R2, R2/BG habitat is readily available. Some caution must be exercised when specific mitigation plans are formulated so that spawning sites remain undisturbed.

TABLE 5.1
SPAWNING SITES

TOTAL NUMBER OF SPAWNING SITES

	Oldman Mainstem	North Fork	Crowsnest	Castle	Total
Brown Trout	0	0	4	0	4
Rainbow Trout	0	3(1)	9	6(1)	18
Mountain Whitefish	10	5	7	3	25

NUMBER OF SPAWNING SITES BELOW FSL

	Oldman Mainstem	North Fork	Crowsnest	Castle	Total
Brown Trout	0	0	0	0	0
Rainbow Trout	0	1(1)	1	3(1)	5
Mountain Whitefish	10	2	1	1	14

NOTE: (1) Estimated

The loss of overwintering habitat to the reservoir will not be mitigated since is has been assumed in the assessments of fishery impacts that the reservoir will provide adequate overwintering habitat (Alberta Environment, 1987c). Both of these assumptions need to be confirmed during the monitoring phase of the mitigation activities, as discussed in detail in the implementation section of this report.

Utilizing the definition of valuable habitat provided in Table 4.5 a definition of critical fisheries habitat may be made. This is valuable fish habitat utilized by individual species <u>below FSL</u> (habitat lost due to inundation), and is presented in Table 5.2 to Table 5.5 inclusive, and Figure 5.3 to Figure 5.6, inclusive.

Table 5.2

CASTLE RIVER
CRITICAL FISHERIES HABITAT BELOW RESERVOIR FSL

SPECIES	LIFESTAGE	TYPE	HABITAT LOST AREA(sm)	NUMBER
RAINBOW TROUT	JUVENILE	RF/BG	0	
		RF	27125	
		RA/BG	30263	
			57388	
	ADULT	R1	66063	
		P1		5
		R2/BG	12600	
			78663	5
MOUNTAIN WHITEFISH	JUVENILE	RF/BG	0	
		RF	27125	
		R3/BG	1600	
		R3	33300	
			62025	
	ADULT	RA/BG	30263	
		R2/BG	12600	
		R1	66063	
		P1		5
		RA	122764	
		R2	86513	
			318203	5

CASTLE RIVER

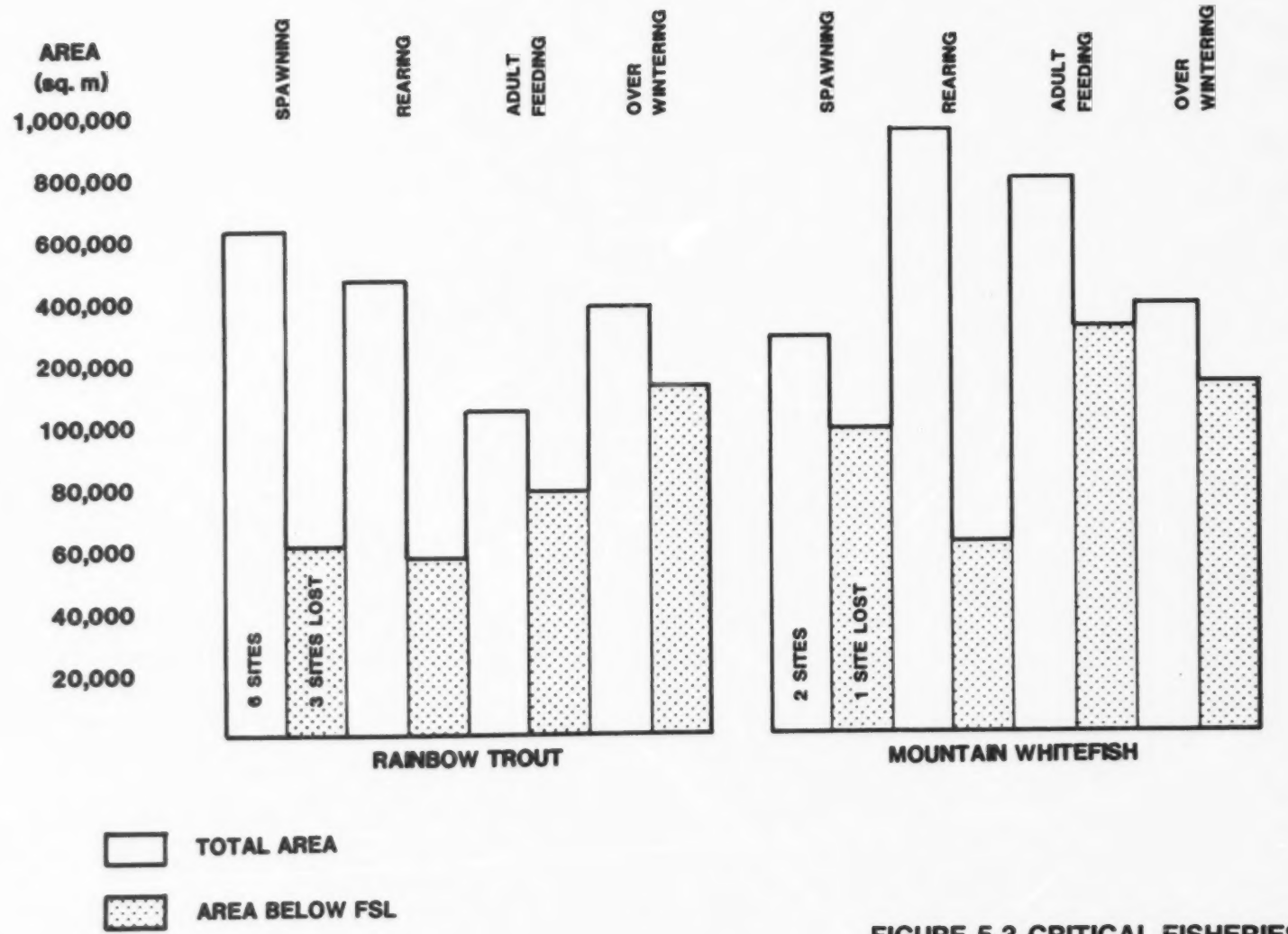


FIGURE 5.3 CRITICAL FISHERIES HABITAT

Table 5.3
CROWSNEST RIVER
CRITICAL FISHERIES HABITAT BELOW RESERVOIR FSL

SPECIES	LIFESTAGE	TYPE	HABITAT LOST AREA(sm)	NUMBER
BROWN TROUT	JUVENILE	RA/BG	8148	
		R1	18075	
		R2/BG	2875	
			29098	
	ADULT	R1	18075	
		P1		3
		R2/BG	2875	
			20950	3
RAINBOW TROUT	JUVENILE	RF/BG	8910	
		RF	55830	
		RA/BG	8148	
			72888	
	ADULT	R1	18075	
		P1		3
		R2/BG	2875	
			20950	3
MOUNTAIN WHITEFISH	JUVENILE	RF/BG	8910	
		RF	55830	
		R3/BG	1705	
		R3	88790	
			155235	
	ADULT	RA/BG	8148	
		R2/BG	2875	
		R1	18075	
		P1		3
		RA	16680	
		R2	17953	
			66713	3

CROWSNEST RIVER

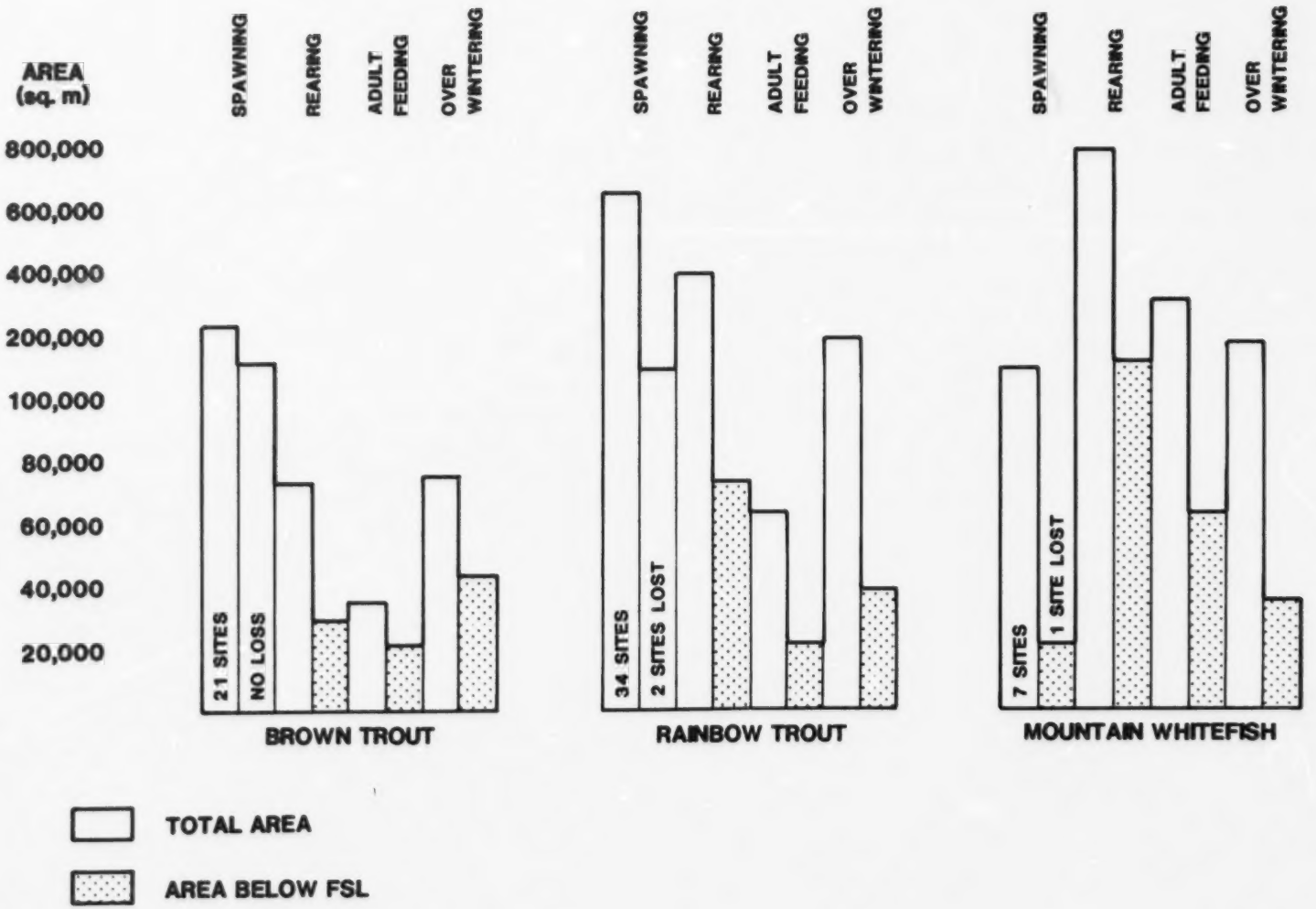


FIGURE 5.4 CRITICAL FISHERIES HABITAT

Table 5.4
OLDMAN RIVER NORTH FORK
CRITICAL FISHERIES HABITAT BELOW RESERVOIR FSL

SPECIES	LIFESTAGE	TYPE	HABITAT LOST AREA(sm)	NUMBER
RAINBOW TROUT	JUVENILE	RF/BG	0	
		RF	56663	
		RA/BG	9225	
			65888	
	ADULT	R1	34450	
		P1		2
		R2/BG	5850	
			40300	2
MOUNTAIN WHITEFISH	JUVENILE	RF/BG	0	
		RF	56663	
		R3/BG	0	
		R3	7863	
			64526	
	ADULT	RA/BG	9225	
		R2/BG	5850	
		R1	34450	
		P1		2
		RA	32275	
		R2	27500	
			109300	2

OLDMAN RIVER - NORTH FORK

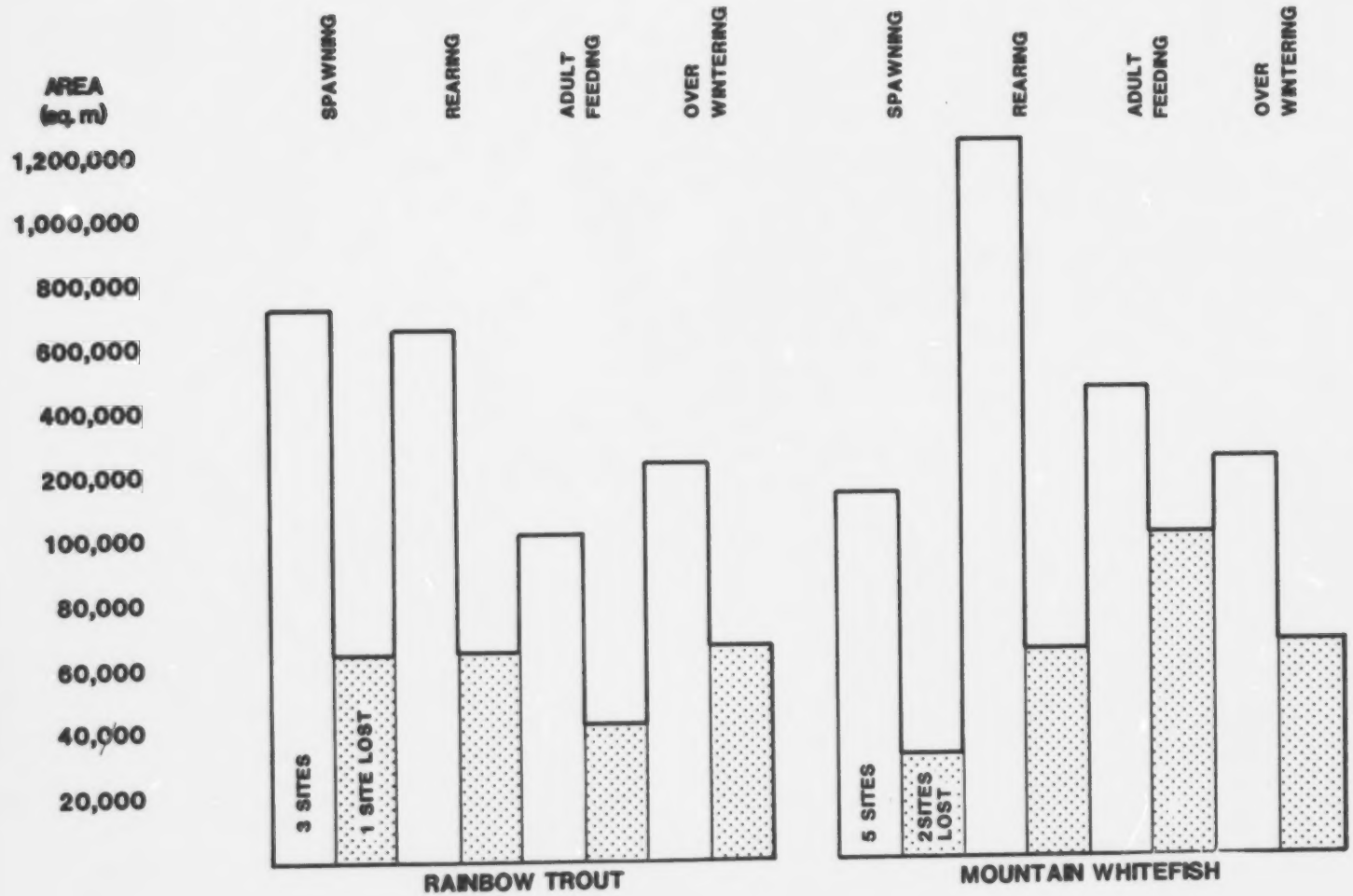


FIGURE 5.5 CRITICAL FISHERIES HABITAT

Table 5.5
OLDMAN RIVER MAIN STEM
CRITICAL FISHERIES HABITAT BELOW RESERVOIR FSL

SPECIES	LIFESTAGE	TYPE	HABITAT LOST AREA(sm)	NUMBER
RAINBOW TROUT	JUVENILE	RF/BG	0	
		RF	46738	
		RA/BG	25963	
			72701	
	ADULT	R1	84763	
		P1		0
		R2/BG	0	
			84763	
MOUNTAIN WHITEFISH	JUVENILE	RF/BG	0	
		RF	46738	
		R3/BG	0	
		R3	85050	
			131788	
	ADULT	RA/BG	25963	
		R2/BG	0	
		R1	84763	
		P1		2
		RA	138188	
		R2	239113	
			488027	2

OLDMAN RIVER - MAIN STEM

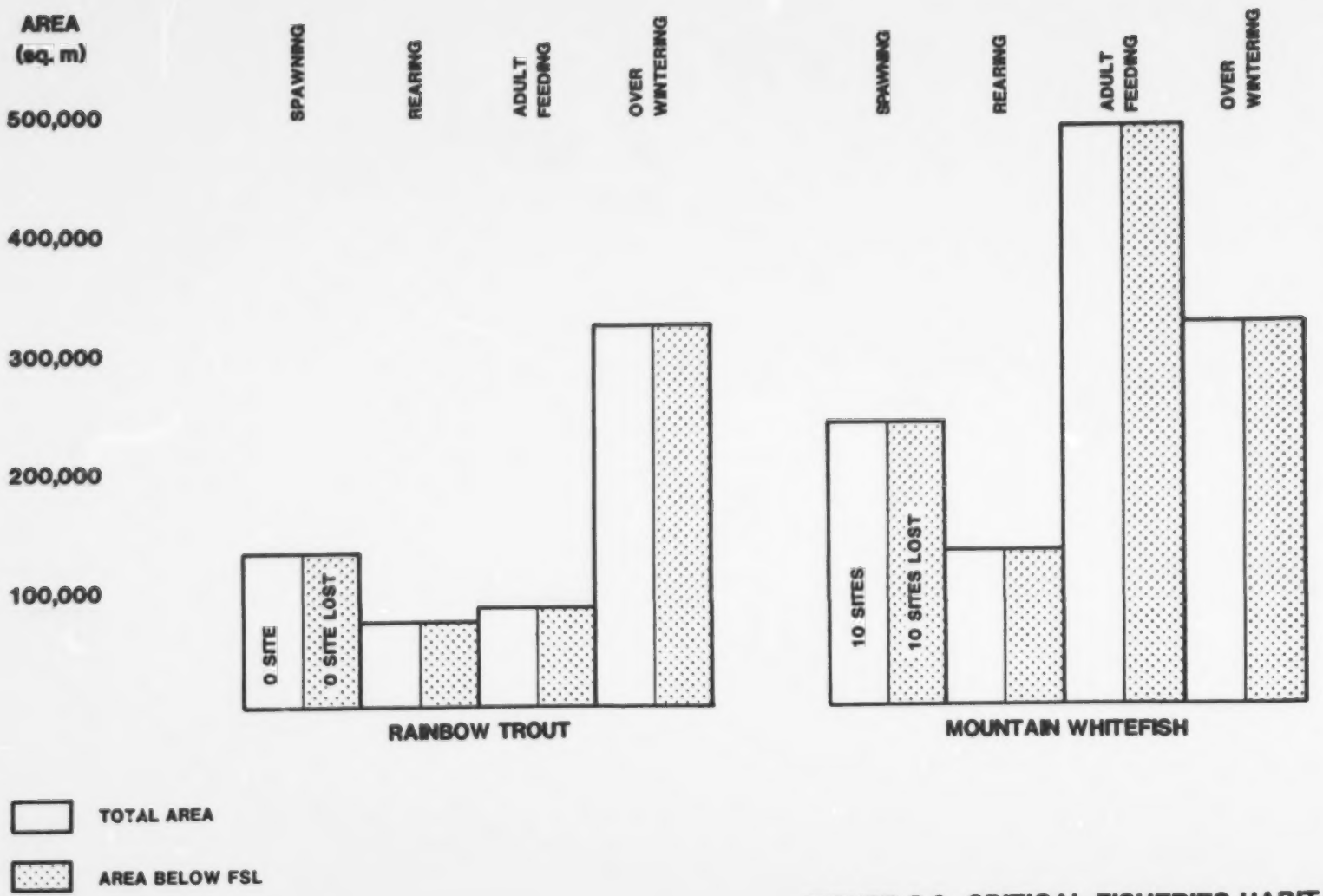


FIGURE 5.6 CRITICAL FISHERIES HABITAT

As an indication of the severity of loss of critical fisheries habitat (juvenile and adult habitat with use ratings of 4 and 5) a comparison of the loss of critical habitat to the total amount of critical habitat in the surveyed reach of the Oldman River system, is presented in Tables 5.6 to 5.9, inclusive. **We stress that the comparison is between lost habitat and the extended surveyed habitat, but not the total habitat in the system since the headwaters of the mainstems, and headwater tributaries, have not been included.** Nevertheless, it is apparent from inspection of the tables that the loss of some critical habitat is significant.

Table 5.6
LOST CRITICAL HABITAT - CASTLE RIVER

SPECIES	LIFESTAGE	TOTAL HABITAT (sm)	LOST HABITAT (sm)	%LOST
RAINBOW TROUT	JUVENILE	460,552	57,388	12%
	ADULT	122,940	78,663	64%
MOUNTAIN WHITEFISH	JUVENILE	957,465	62,025	6%
	ADULT	797,750	318,203	40%

NOTES: TOTAL HABITAT REFERS TO TOTAL HABITAT OF SURVEYED DATA BASE, NOT ENTIRE RIVER SYSTEM

LOST HABITAT REFERS TO HABITAT LOST DUE TO RESERVOIR INUNDATION

Table 5.7
LOST CRITICAL HABITAT - CROWSNEST RIVER

SPECIES	LIFESTAGE	TOTAL HABITAT (sm)	LOST HABITAT (sm)	%LOST
BROWN TROUT	JUVENILE	70,204	29,098	41%
	ADULT	35,051	20,950	60%
RAINBOW TROUT	JUVENILE	399,670	72,888	18%
	ADULT	63,545	20,950	33%
MOUNTAIN WHITEFISH	JUVENILE	782,365	155,235	20%
	ADULT	308,347	63,713	21%

NOTES: TOTAL HABITAT REFERS TO TOTAL HABITAT OF SURVEYED DATA BASE, NOT ENTIRE RIVER SYSTEM

LOST HABITAT REFERS TO HABITAT LOST DUE TO RESERVOIR INUNDATION

Table 5.8
LOST CRITICAL HABITAT - OLDMAN RIVER NORTH FORK

SPECIES	LIFESTAGE	TOTAL HABITAT (sm)	LOST HABITAT (sm)	%LOST
RAINBOW TROUT	JUVENILE	660,059	65,888	10%
	ADULT	111,294	40,300	36%
MOUNTAIN WHITEFISH	JUVENILE	1,241,639	64,526	5%
	ADULT	463,562	109,300	24%

NOTES: TOTAL HABITAT REFERS TO TOTAL HABITAT OF SURVEYED DATA BASE, NOT ENTIRE RIVER SYSTEM

LOST HABITAT REFERS TO HABITAT LOST DUE TO RESERVOIR INUNDATION

Table 5.9
LOST CRITICAL HABITAT - OLDMAN RIVER MAIN STEM

SPECIES	LIFESTAGE	TOTAL HABITAT (sm)	LOST HABITAT (sm)	%LOST
RAINBOW TROUT	JUVENILE	72,701	72,701	100%
	ADULT	84,763	84,763	100%
MOUNTAIN WHITEFISH	JUVENILE	131,788	131,788	100%
	ADULT	488,027	488,027	100%

NOTES: TOTAL HABITAT REFERS TO TOTAL HABITAT OF SURVEYED DATA BASE, NOT ENTIRE RIVER SYSTEM

LOST HABITAT REFERS TO HABITAT LOST DUE TO RESERVOIR INUNDATION

5.3.3.4 Wave Action on Reservoir

Analyses have been completed (UMA, 1986) to assess wave action on the reservoir after the dam construction.

Table 5.10 and Figure 5.7 present in tabular and diagrammatic form the wind speeds and directions for Pincher Creek (AES, 1987).

The action of wind on the Oldman River Reservoir will produce wind setup, waves and wave runup. The crest elevation of the dam and dyke has been established at 6.9 m above FSL to permit the reservoir to surcharge during extreme floods. The maximum fetch has been calculated at 3.4 km and 9.4 km for the dam and dyke, respectively. The corresponding 1 in 100 year overwater wind velocities for the dam and dyke were estimated by UMA as 160 km/h and 190 km/h, giving wave runups of 2m on the dam and 3.5 m on the dyke, respectively. Wind setup was estimated as 0.15 m. These values correspond to wave heights on the reservoir of 2.3 m in a 1 in 100 year return period event.

TABLE 5.10

WIND SUMMARY DATA
PINCHER CREEK ALTA.

PERIOD 1960-80 PERIODE

Lat. 49°30'N Long. 113°57'W

Elevation 1155 m Altitude

	JAN JANV	FEB FEV	MAR MARS	APR AVR	MAY MAI	JUN JUIN	JUL JUIL	AUG AOUT	SEP SEPT	OCT OCT	NOV NOV	DEC DEC	YEAR ANNUEL	
PERCENTAGE FREQUENCY														**FRÉQUENCE EN %**
N	0 2	0 3	0 7	1 5	1 0	0 9	0 8	0 6	1 0	0 5	0 3	0 2	0 7	N
NNE	0 4	0 5	1 0	2 0	1 5	0 9	0 8	0 6	1 2	0 3	0 3	0 2	0 8	NNE
NE	1 4	1 2	2 2	2 8	2 6	2 1	2 3	2 0	2 2	1 3	1 0	1 0	1 8	NE
ENE	1 4	1 2	1 8	2 2	2 3	1 4	1 4	1 8	1 6	1 1	1 4	1 1	1 6	ENE
E	6 0	4 6	4 3	3 9	3 7	2 3	3 5	3 3	2 9	2 1	3 8	3 9	3 7	E
ESE	4 6	4 3	3 1	2 1	2 6	2 1	2 3	2 4	1 9	1 4	3 1	3 3	2 8	ESE
SE	3 3	2 7	2 6	2 4	2 6	2 3	2 9	2 3	2 0	1 3	2 3	3 2	2 5	SE
SSE	1 1	1 2	1 3	1 3	2 0	1 7	1 7	1 0	1 0	0 7	1 2	1 2	1 3	SSE
S	1 4	1 4	2 5	2 4	2 2	2 0	2 4	2 1	2 0	1 7	1 6	1 4	1 9	S
SSW	0 8	0 9	1 3	1 6	1 3	1 4	1 8	1 9	1 9	1 4	1 0	0 9	1 3	SSW
SW	3 8	3 9	5 5	6 5	6 7	6 5	8 8	8 8	7 4	6 1	4 8	3 4	6 0	SW
WSW	14 7	15 8	18 7	21 0	17 7	20 0	16 8	17 5	19 0	22 4	17 8	15 2	18 1	WSW
W	39 1	42 2	34 8	31 6	32 7	33 1	30 1	31 8	34 0	43 0	40 9	42 8	36 3	W
WNW	5 7	4 7	4 7	4 6	5 6	6 0	6 2	7 0	5 2	4 8	5 1	6 0	5 5	WNW
NW	0 9	1 0	1 2	1 6	2 6	2 5	1 9	2 0	1 9	1 2	0 8	0 9	1 5	NW
NNW	0 2	0 2	0 5	0 8	1 2	0 7	0 6	0 5	0 6	0 3	0 2	0 2	0 5	NNW
Calm	15 0	13 9	13 8	11 7	11 7	14 1	15 7	14 6	14 2	10 4	14 4	15 1	13 7	Calme
MEAN WIND SPEED IN KILOMETRES PER HOUR														
VITESSE MOYENNE DES VENTS EN KILOMETRES PAR HEURE														
N	11 3	13 0	13 9	16 7	12 5	13 8	10 4	11 2	13 7	11 4	9 4	8 3	12 1	N
NNE	15 0	17 6	16 6	16 7	16 5	16 6	15 1	11 2	13 2	12 0	12 1	10 9	14 5	NNE
NE	11 7	12 1	12 7	13 6	12 8	11 7	11 2	11 1	11 3	11 8	12 1	11 0	11 9	NE
ENE	11 7	12 5	12 5	11 4	11 8	12 1	11 7	10 3	11 2	11 5	11 8	11 7	11 7	ENE
E	10 1	9 7	10 0	10 0	10 8	9 8	9 9	9 1	9 1	10 0	9 8	9 8	9 8	E
ESE	10 6	10 6	9 8	10 2	11 0	10 6	10 3	10 6	8 7	9 5	9 4	9 8	10 1	ESE
SE	10 3	9 9	8 6	9 6	10 4	11 0	10 4	10 1	9 0	8 8	9 5	10 2	9 8	SE
SSE	11 2	10 9	9 7	10 9	11 0	12 3	11 5	10 0	9 5	9 5	9 9	9 8	10 5	SSE
S	9 2	9 6	11 1	12 0	11 0	11 2	10 6	10 4	9 2	8 9	9 2	11 1	10 3	S
SSW	11 5	11 3	11 3	13 2	13 4	12 5	12 5	12 9	11 7	12 1	13 0	11 2	12 2	SSW
SW	19 7	18 2	18 4	19 7	18 5	16 6	16 8	17 6	17 4	18 5	18 9	19 8	18 3	SW
WSW	36 1	34 1	29 4	30 3	26 4	26 3	22 6	23 5	25 6	31 2	30 8	32 9	29 1	WSW
W	35 7	33 0	28 6	27 7	24 5	24 0	21 7	21 4	24 4	30 2	31 2	32 6	27 9	W
WNW	19 8	17 4	15 7	14 8	14 7	15 7	15 0	13 6	15 1	17 5	19 0	20 5	16 6	WNW
NW	12 8	11 8	12 5	12 0	13 4	13 1	10 5	10 1	11 8	11 8	12 2	15 0	12 3	NW
NNW	11 8	12 1	12 2	13 5	16 9	14 1	11 3	11 2	13 7	14 6	11 4	14 5	13 1	NNW
All Directions														**Toutes directions**
	23 5	22 9	19 7	20 1	17 9	17 6	15 2	15 5	17 4	23 3	21 9	22 7	19 8	
Maximum Hourly Speed														**Vitesse horaire maximale**
	137 W	109 WSW	109 W	93 W	80 SW	90 W	72 W	89 WSW	90 W	106 WSW	135 WSW	122 WSW	137 W	
Maximum Gust Speed														**Vitesse maximale des rafales**
	161 W	150 WSW	153 W	138 W	138 WSW	130 W	116 SVL	132 WSW	117 W	154 WSW	177 WSW	161 SVL	177 WSW	

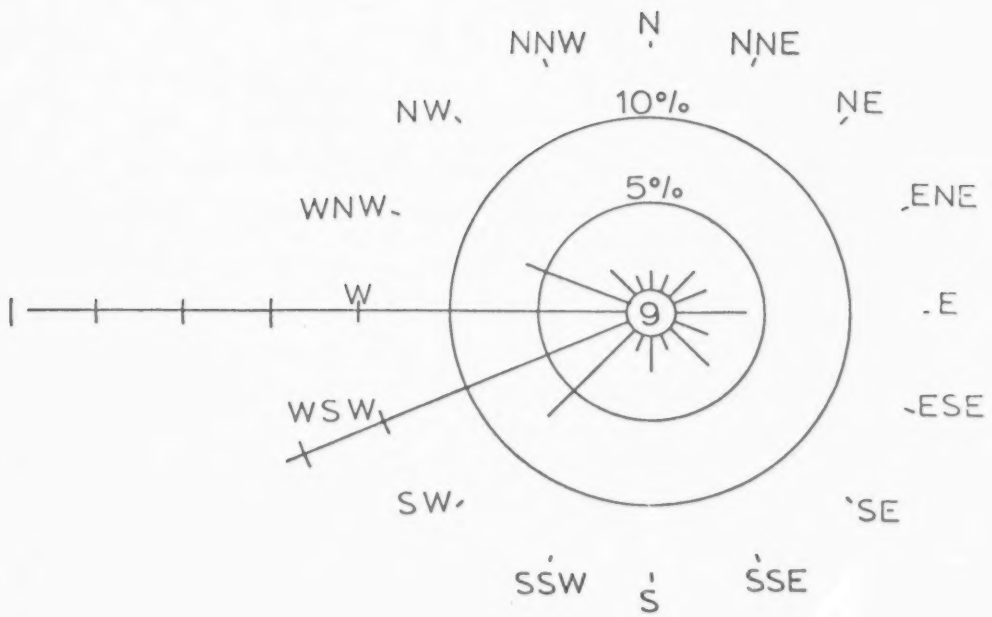
Height of anemometer 8.8 m hauteur de l'anémomètre

STATION INFORMATION

Station is located on high ground in the south west corner of the town of Pincher Creek. From the instrument area the terrain slopes sharply down to the north and east to the Pincher Creek valley. To the south and west the country is rolling farms and ranchlands. Station relocated to airport June 1979.

DONNÉES RELATIVES À LA STATION

La station se trouvait sur une hauteur, au coin sud-ouest de la ville de Pincher Creek. Le terrain va en descendant abruptement de l'emplacement des instruments en direction du nord et de l'est vers la vallée de Pincher Creek. On trouve au sud et à l'ouest des terres arables et des pâturages ondulées. La station a été réinstallée à l'aéroport en juin 1979.



PERCENT CALM SHOWN ON INNER CIRCLE

FIGURE 5.7
ANNUAL PERCENTAGE OF WIND (1961 to 1966)
PINCHER CREEK

5.3.4 Downstream of the Dam

5.3.4.1 Channel Degradation

After construction of the dam the river bed below the dam will degrade slightly due to the entrapment of coarse sediment in the reservoir. An ultimate degradation of 0.5 m is predicted for the river bed in the reach below the dam site. Degradation will be limited to approximately 2 km below the dam site. The time to reach the ultimate degradation is estimated as approximately 25 years (NHCL, 1987).

NHCL assumed that peak flows would be similar to present conditions; i.e. the reservoir would be effectively run-of-river during high flow events, which are most important for degradation; and that the surficial bed material that currently protects the bed would be removed to expose the finer underlying material.

The bed material of the Oldman River in the reach below the dam site consists of coarse gravel and cobbles. The bed is paved, the surface material being coarser than the sub-surface material. NHCL (1987) concluded that the surface layer would remain stable except during rare floods.

Since the sub-surface material contains sufficiently large stones, re-armouring of the bed will occur. The river banks also contain large quantities of coarse material to assist in the armouring process.

The degradation of the river channel bed is a natural process. There are no engineering works which will stop this from happening without armouring the channel (rock riprap). This would produce the same type of substrate as will occur naturally.

5.3.4.2 Water Quality and Water Temperature

The reservoir will delay spring warming and fall cooling of the downstream Oldman River (HydroQual, 1985). HydroQual concluded that summer maximum river temperatures below the dam will be reduced by about 5-6^{o}C with bottom release. The timing of summer peak river temperatures will be offset by approximately six weeks. HydroQual predicted the cooling effect of the reservoir on the downstream Oldman River could be experienced as far downstream as Ft. MacLeod (60 km).

HydroQual predicted that the reservoir will dampen the natural seasonal pattern in Oldman River water chemistry. Normally high winter concentrations for major ions will be reduced, while low spring concentrations will be increased. Total and dissolved phosphorous concentrations will be reduced by sedimentation, as will iron, manganese and trace metals. Downstream ammonia, nitrate and dissolved organic carbon levels will be seasonally increased.

5.3.4.3 Flow Regime

The construction of the dam will cause a reduction in spring freshet flows (May, June, July) downstream of the dam and an increase in the remaining months of the year (Table 5.11). For the minimum flow conditions, which most directly affect the fisheries resource in the Oldman River downstream of the dam, there is little change for either spring spawning (March, April) or fall spawning (October, November) species. There is, therefore, no adverse impact on fisheries downstream of the Dam to be expected due to stream flow conditions themselves.

TABLE 5.11

OLDMAN RIVER
FLOWS AT BROCKET
(cms)

MONTH	MEAN		MINIMUM		MAXIMUM	
	Natural	Regulated*	Natural	Regulated*	Natural	Regulated*
January	8.2	10.3	4.4	7.9	17.6	17.6
February	8.0	10.2	4.1	7.8	17.2	12.3
March	12.0	10.6	3.7	7.7	35.5	24.3
April	35.4	17.1	7.8	8.5	93.7	93.4
May	133.8	86.5	37.8	21.1	298.5	298.0
June	159.5	145.4	34.6	26.9	437.7	436.4
July	57.1	62.0	12.6	32.1	149.2	145.7
August	23.3	50.4	5.1	28.1	90.9	78.2
September	17.5	34.6	7.6	19.9	73.7	72.0
October	16.5	23.5	7.0	19.2	49.4	48.2
November	12.5	11.5	6.5	7.7	24.7	21.2
December	9.3	10.5	2.5	7.7	20.6	19.8

* Regulated at full irrigation development

5.3.4.4 Fisheries Resource

EMA (1987b) have provided the relationships between habitat availability and discharge for selected fish species downstream of the dam. The habitat availability-discharge relationships contained in that report were not all modified for their analysis due to a lack of site-specific data on habitat preference criteria for the Oldman River (EMA, 1987b, pg.1). As those authors note:

> "A high degree of confidence may be placed on the mountain whitefish and juvenile rainbow trout results."

The significance of this finding to the present study is that any attempts at fishery mitigation downstream of the dam would focus naturally on those mountain whitefish populations which currently constitute the principal sport-fish population downstream.

The available flow data derived from operational parameters for the reservoir at full irrigation development consist of mean monthly and minimum flow by month for the three downstream stations (Brocket, Below LNID and Lethbridge) (Hagerman, 1987 personal communication). These minimum flows fall at the low end of the discharge component of the discharge/habitat availability relationship cited by EMA (1987b), for mountain whitefish.

If a tailwater fishery involving trout is required as a component of riverine mitigation, then significant problems occur with respect to rainbow trout for which mitigation has been suggested (due to isolation from spawning grounds which occur above the dam). First, the high regulated spring release flows (May onward) would appear to necessitate the creation of off-channel spawning areas protected from the

high flows. This implies an engineering/construction cost for a permanent flow barrier, although this could be accomplished during the construction of the dam itself.

Second, although the water temperature regime model for reservoir releases has yet to be finalized, the nature of the bottom-water release from the reservoir dictates that the water temperatures during the rainbow trout spring spawning season will not approach optimum levels.

Therefore, if a self-sustaining tailwater trout fishery is required, significant modification of the above-noted scheme would be necessary:

1. The temperature regime of the reservoir outlet flow would have to be modified.

2. If the thermal regime is not amenable to change, then the creation of spawning side-channels would have to be considered downstream of the tailwater zone where optimum water temperatures for rainbow trout spawning are more likely to occur.

3. If a tailwater zone fishery at the projected thermal regime is required there are few options other than to modify, or change, the trout species.

4. If mitigation for potential rainbow trout losses downstream, due to the dam, is required and none of the above-noted options for rainbow trout spawning viability can be met, then significant augmentation of the existing population would be necessary on a continual basis. Obviously, this implies the need for stocking from hatchery supplies.

6.0 MITIGATION PLAN

6.1 Physical Riverine Techniques

The available literature on physical techniques for riverine enhancement methodologies was assessed and the report entitled "Stream Enhancement Guide" (Governments of Canada, British Columbia, 1986) was judged as the most applicable for the stream habitat in our study region. Those techniques were excerpted and applied in our study in order to act as a guide for any mitigation plans which may be adopted.

6.1.1 General

Physical conditions within the river channel can be modified to improve, or increase, the fishery habitat. However, if the channel modifications are to be permanent and successful, they must be designed on firm river engineering principles. Poorly planned works may actually cause more damage in terms of lost habitat to the natural stream. The following general guidelines should therefore be considered in the design of in-stream habitat mitigative works.

- Pool and riffle areas repeat at approximately 5 to 7 channel widths, regardless of whether the stream has a meandering or straight configuration. This natural stream form must be maintained, and the addition of any devices to improve the rearing habitat must complement the natural stream configuration. This implies a need for careful site-specific evaluations in advance of construction.

- Devices in streams must be located to avoid backflooding the section immediately upstream. Riffles can be flooded out and pools can be reduced to a velocity which is no

longer acceptable to rearing salmonids. In general, stream devices should guide the current rather than dam the flow.

- All stream devices must be constructed in low profile to permit free passage of drifting logs and debris.

- All structures should be built solidly, and of sufficient size to withstand the normal flood flows. They must also be effective during low flow conditions.

- Construction materials should be natural, wherever possible, should be durable enough to withstand freeze-thaw cycles and hydraulic forces, and must be reasonably resistant to decay.

- Devices to improve a specific section of stream must be installed in a manner which will not damage adjacent areas of high value to fish. When heavy equipment is used, it is especially important to avoid traversing good, stable areas of natural stream to reach the section being improved. For instance, to inadvertently destroy 50 metres of stream in order to enhance 10 metres is obviously not prudent.

- All stream work, particularly where heavy equipment is involved, must be timed to avoid conflict with the spawning and incubation periods of the various fish species. Hence, biological evaluations of sensitivities to local fishes must be incorporated into final engineering planning for site-specific engineering works.

- Stream banks must be well protected (revetment) if a stream device accelerates the flow, or turns the flow toward a bank. This is particularly important where

there is a possibility of damaging existing fish habitat or private property.

6.1.2 Physical Mitigative Techniques for the Oldman River

Three specific mitigative techniques have been selected for habitat mitigation upstream of FSL. These are as follows:

1. Create R1 and P1, and RF/BG habitat from R3 habitat (Figures 6.1, 6.1a - 6.1h) . In the fast, shallow R3 habitat, narrow the channel and provide ledges and meanders to reduce the slope and deepen the water. Install bank overhang on the pools at bends.

2. Create RF/BG habitat from R3 habitat (Figures 6.2, 6.2a). In the slow, shallow R3 habitat, narrow the channel and provide riffles and boulder gardens.

3. (a) Create RA/BG habitat from RA habitat by the addition of well placed boulder gardens (Figure 6.3).

   (b) Create R2/BG habitat from R2 habitat by the addition of well placed boulder gardens (Figure 6.3).

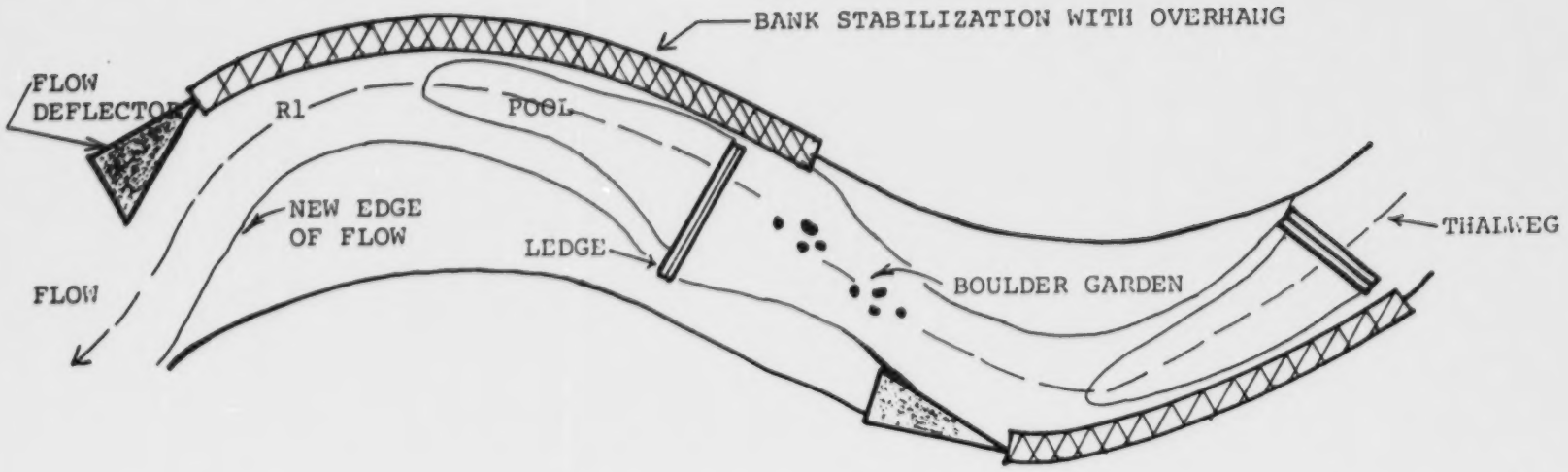
   (c) Create RF/BG, RA, and RF habitat from RF habitat by the addition of well placed boulder gardens (Figure 6.3).

6.1.3 Specific Guidelines for Mitigative Works

6.1.3.1 Pools and Runs

Wing deflectors are a common device for modifying or improving stream channels. They are installed along the upstream edge of a point bar as an erosion-resistant leading edge. A well-constructed system of wing deflectors, alter-

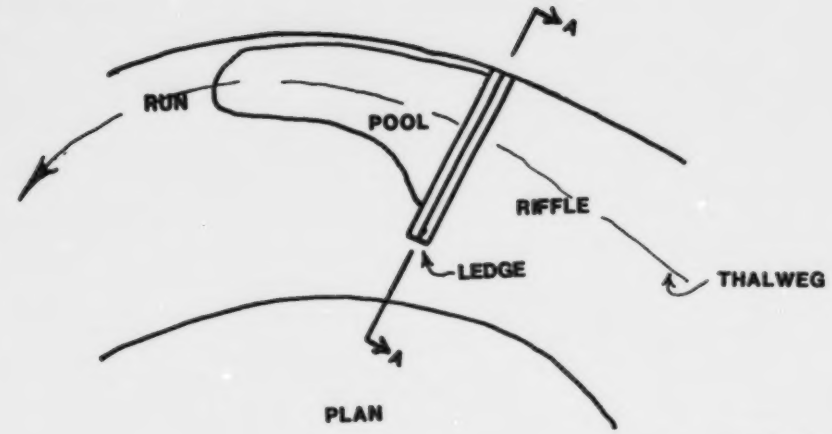
CONVERSION OF R3 (FAST) TO R1, P1 WITH SOME RF/BG



PLAN

- located on meandering stream segment
- Details shown on Figures 6.1A to 6.1H

FIGURE 6.1 TYPE 1 MITIGATION



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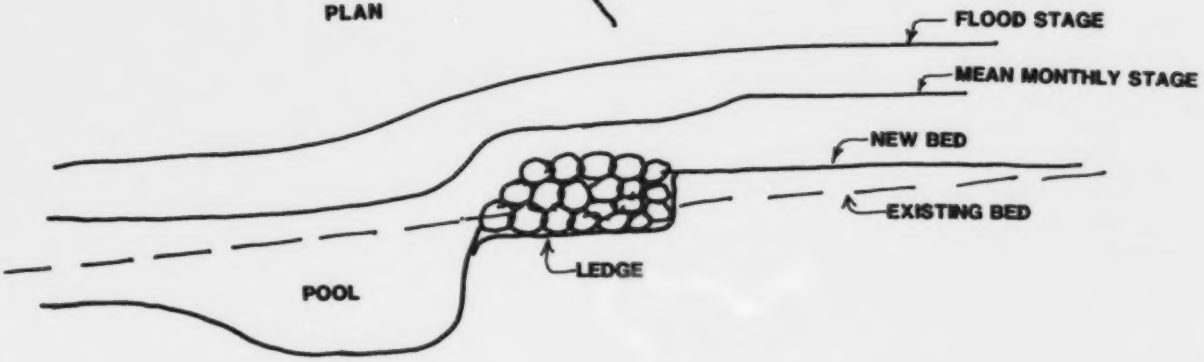
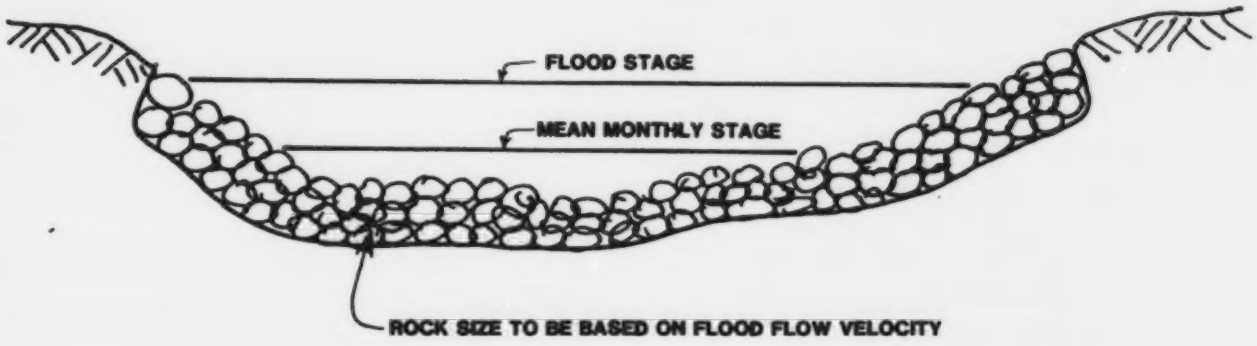


PROFILE



SECTION A-A

FIGURE 6.1A

LEDGE POOL DETAIL

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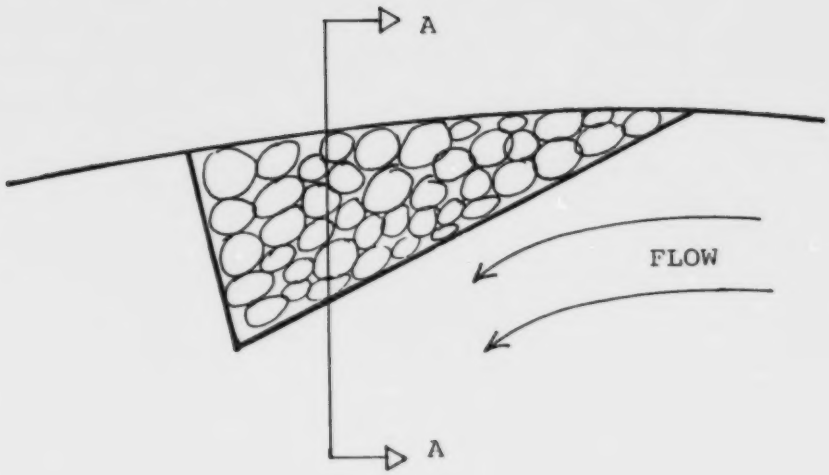
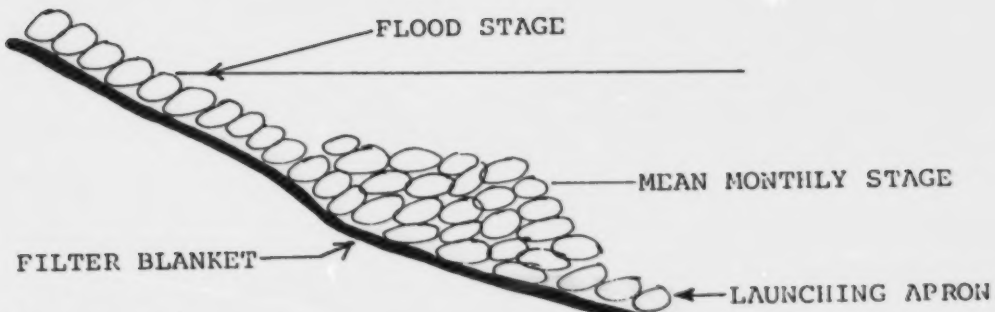
WATER RESOURCES ENGINEERING



PLAN

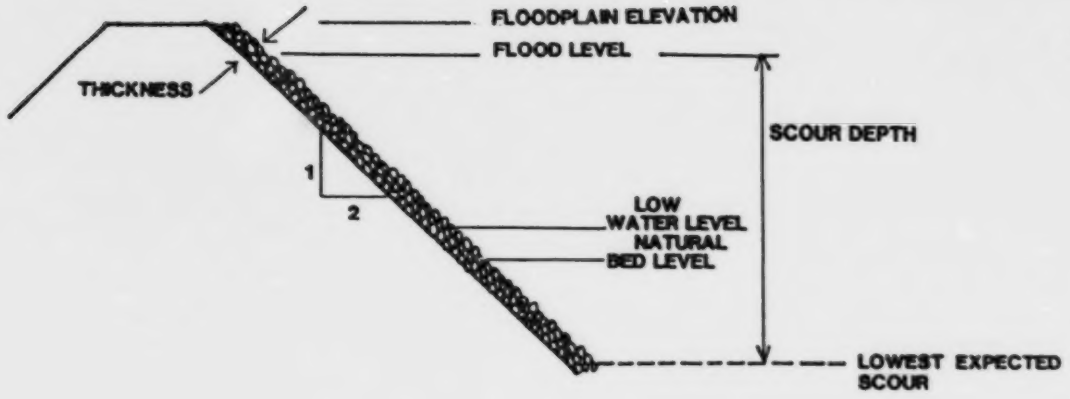


SECTION A-A

- rock size based on flood velocities

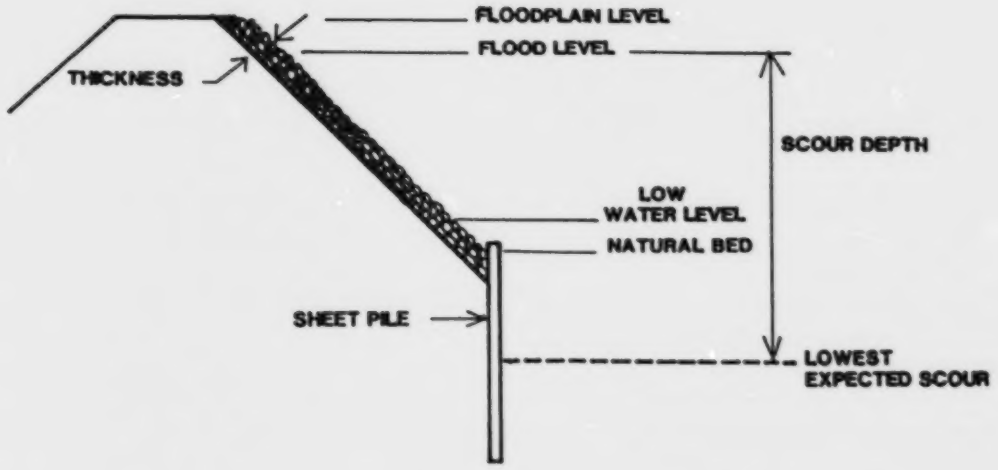
FIGURE 6.1B **FLOW DEFLECTOR**

INSTALLATION A



When toe excavation is permissable in the dry, the stone layer on the embankment is extended at the same slope to the anticipated depth of scour below the design flood stage.

INSTALLATION B



This installation utilizes sheet piles as an alternative for the lower portion of the bank stabilization. The alternative requires further geotechnical analysis.

FIGURE 6.1C BANK STABILIZATION

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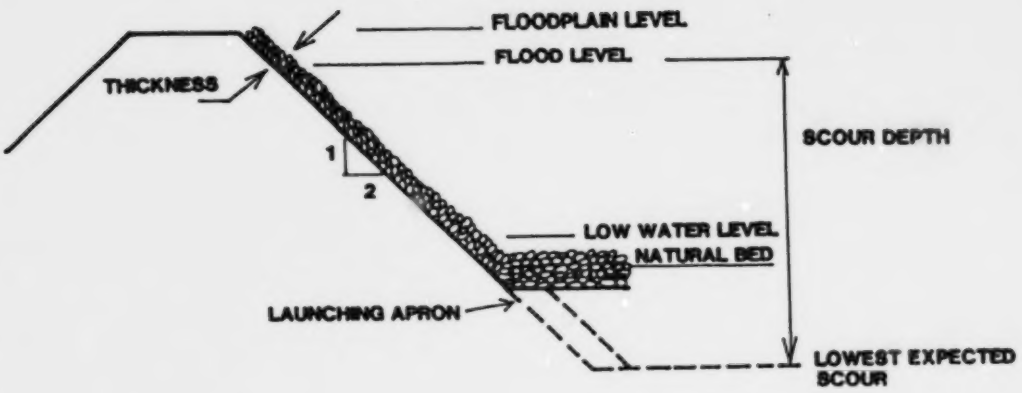
WATER RESOURCES ENGINEERING

INSTALLATION C



When stone is to be placed underwater and appreciable scour is anticipated, a trench should be excavated to permit a thickened toe. The volume of stone in this thickened toe should be adequate to provide the same thickness of erosion protection as above the toe into the anticipated scour hole assuming the hole will adjust to a 2:1 slope.

LAUNCHING APRONS

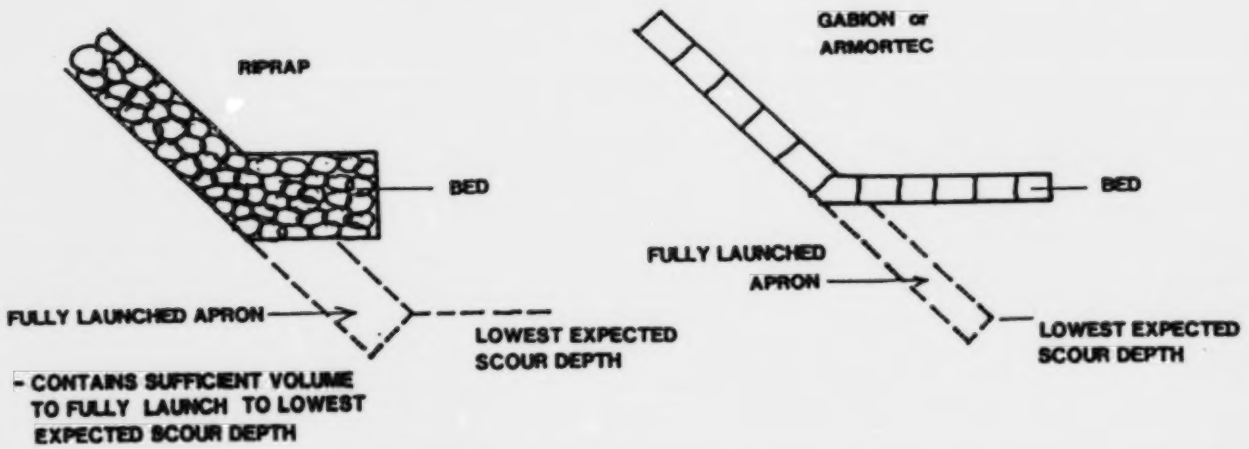


FIGURE 6.1D BANK STABILIZATION

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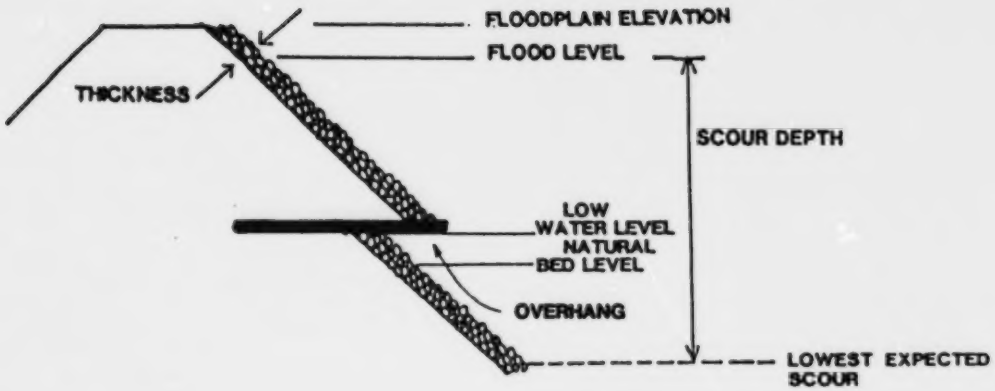

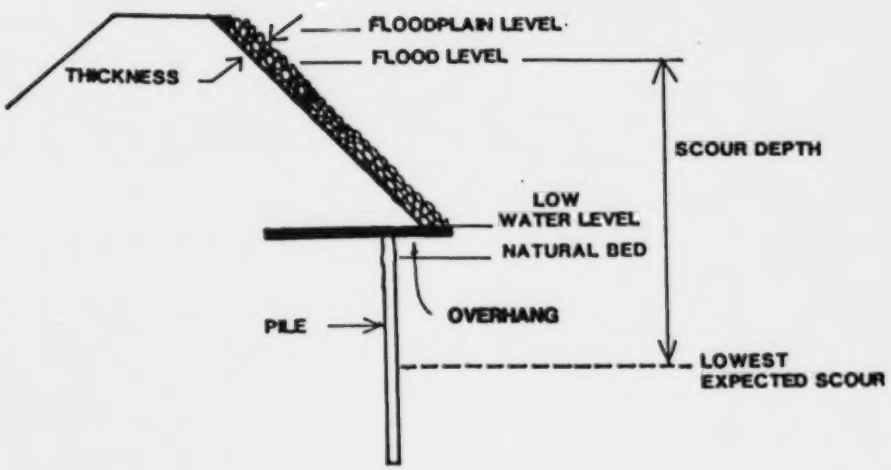

FIGURE 6.1E BANK STABILIZATION WITH OVERHANG

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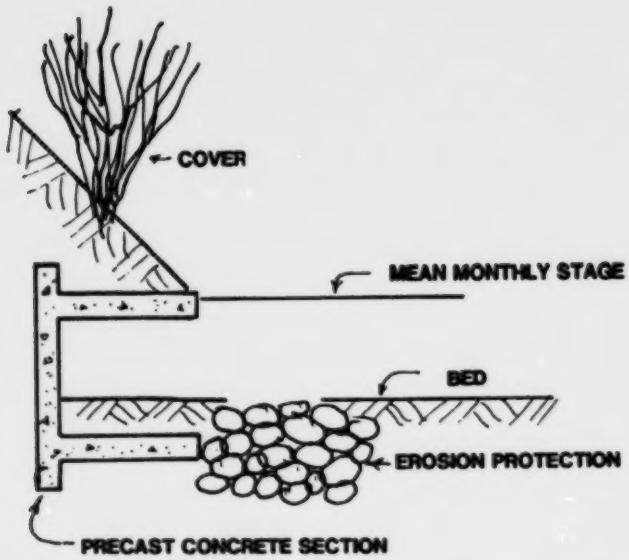


SUITABLE IN LOW FLOW AREAS WHERE POOL DEVELOPMENT IS NOT DESIREABLE, SUCH AS IN SPAWNING AREAS

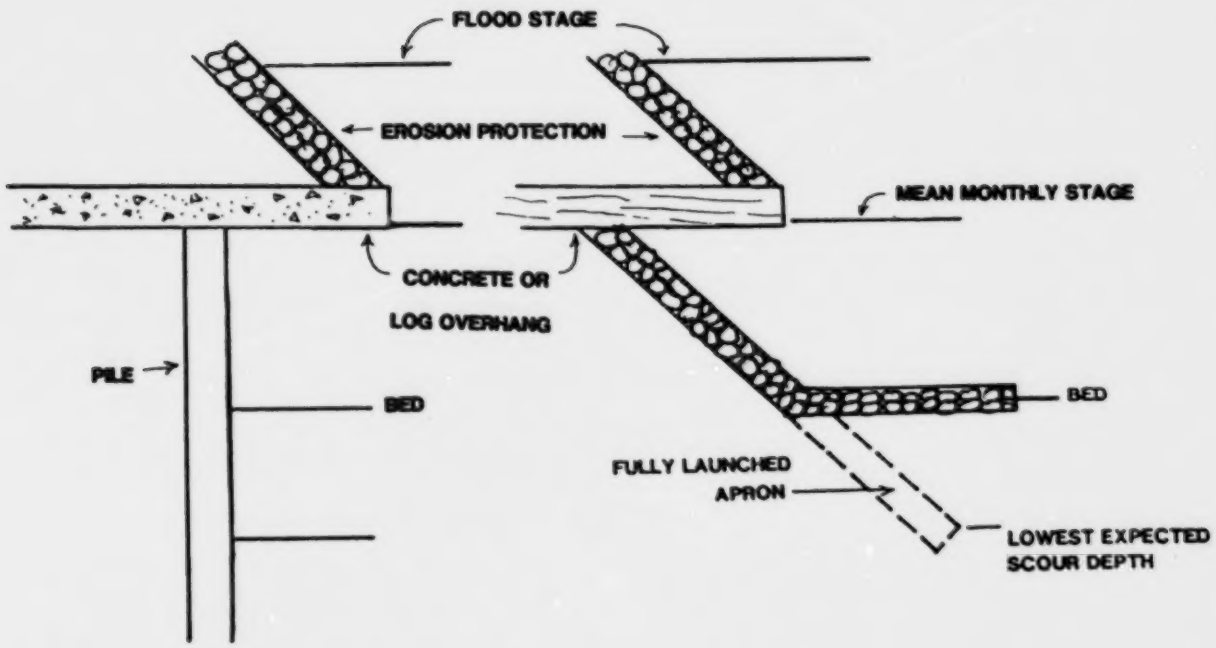
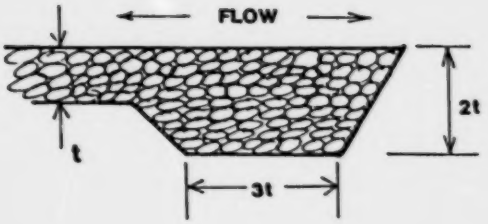
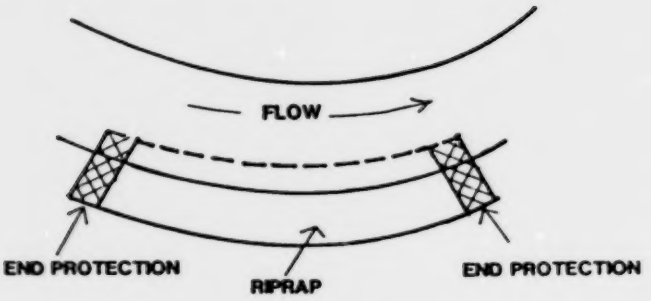


FIGURE 6.1F OVERHANG DETAILS

RIPRAP END PROTECTION



TYPICAL END PROTECTION DETAIL



PLAN VIEW

RIPRAP INSTALLATION DETAIL

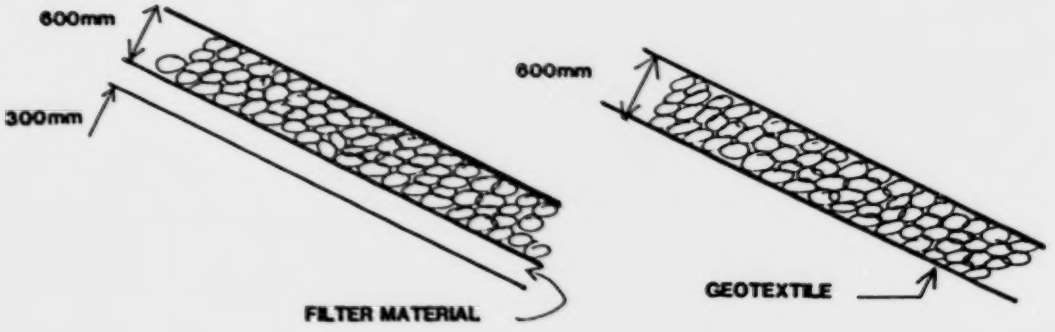


FIGURE 6.1G

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Class I
Nominal 300 mm diameter or 40 kg mass
Allowable local velocity up to 3 m/s
Grading specification:

100%	smaller than	450 mm or	130 kg
at least 20%	larger than	350 mm or	70 kg
at least 50%	larger than	300 mm or	40 kg
at least 80%	larger than	200 mm or	10 kg

Class II
Nominal 500 mm diameter or 200 kg mass
Allowable local velocity up to 4 m/s
Grading specification:

100%	smaller than	800 mm or	700 kg
at least 20%	larger than	600 mm or	300 kg
at least 50%	larger than	500 mm or	200 kg
at least 80%	larger than	300 mm or	30 kg

Class III
Nominal 800 mm diameter or 700 kg mass
Allowable local velocity up to 4.7 m/s
Grading specification:

100%	smaller than	1200 mm or	2300 kg
at least 20%	larger than	900 mm or	1100 kg
at least 50%	larger than	800 mm or	700 kg
at least 80%	larger than	500 mm or	200 kg

NOTE:
- Percentages quoted are by mass; the sizes quoted are equivalent spherical diameters. Where

$$\text{DIAMETER} = 1.24\sqrt[3]{\text{VOLUME}}$$

- for a size mass conversion chart see figure below
- Placement thickness is 2 times the mean diameter

Source (Neill, 1973)

SUGGESTED STONE RIPRAP GRADINGS

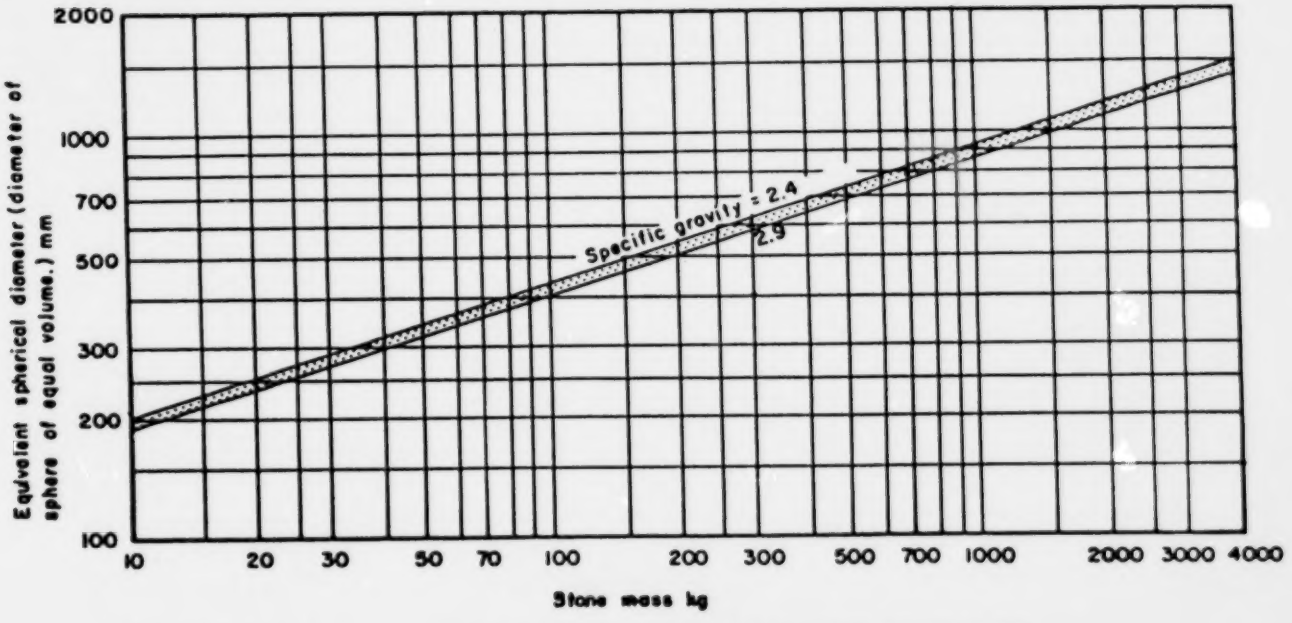
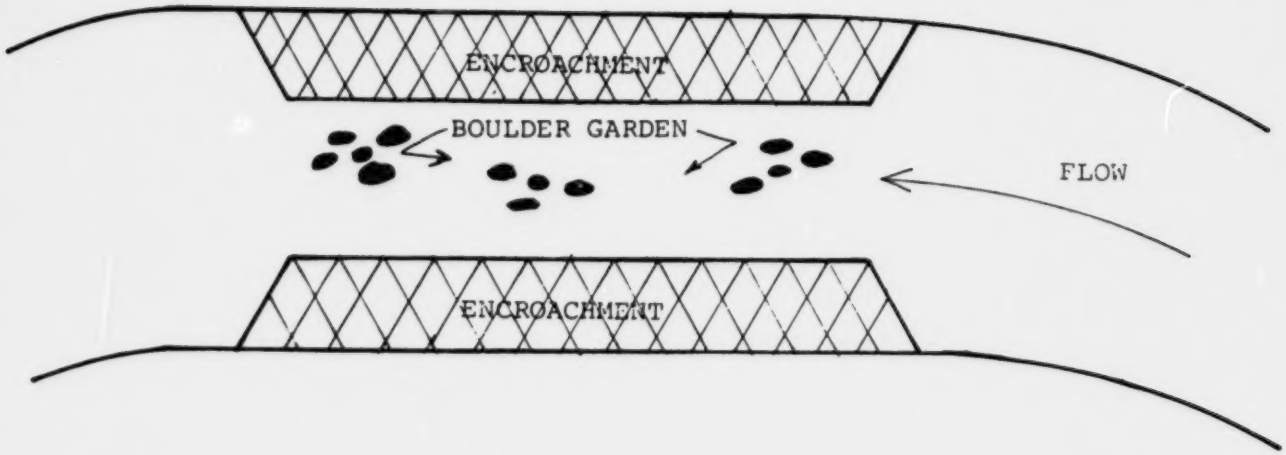


FIGURE 6.1H **STONE SIZE MASS CONVERSION CHART**

CONVERSION OF R3 (SLOW) TO RF/BG



PLAN

- located on Straight Stream segment
- for details see Figure 6.2A

FIGURE 6.2 TYPE 2 MITIGATION

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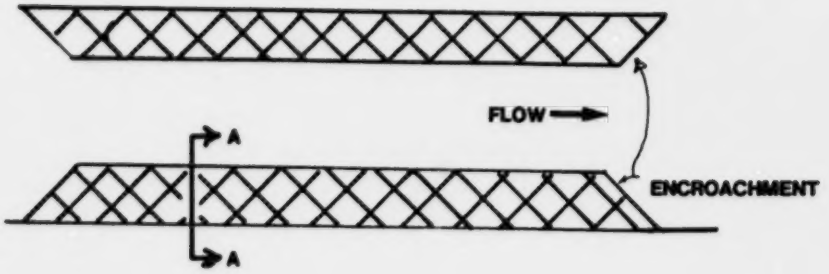
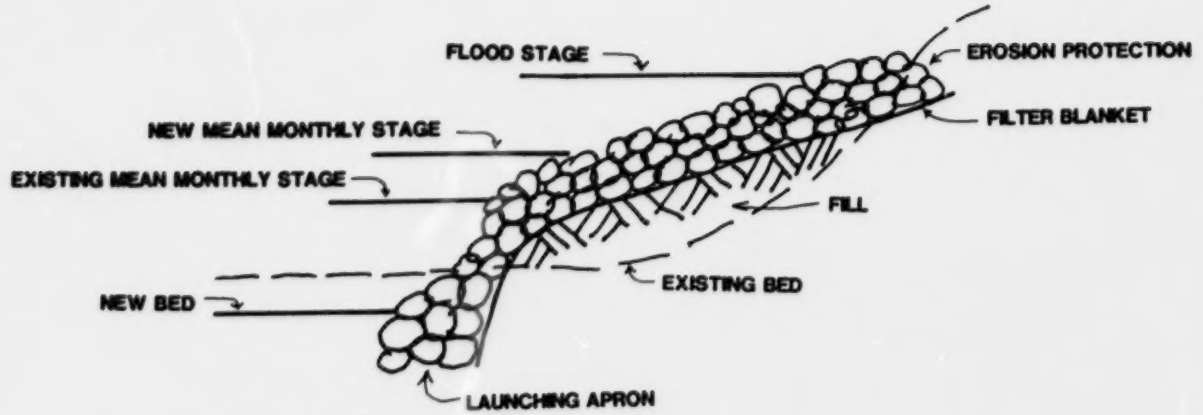
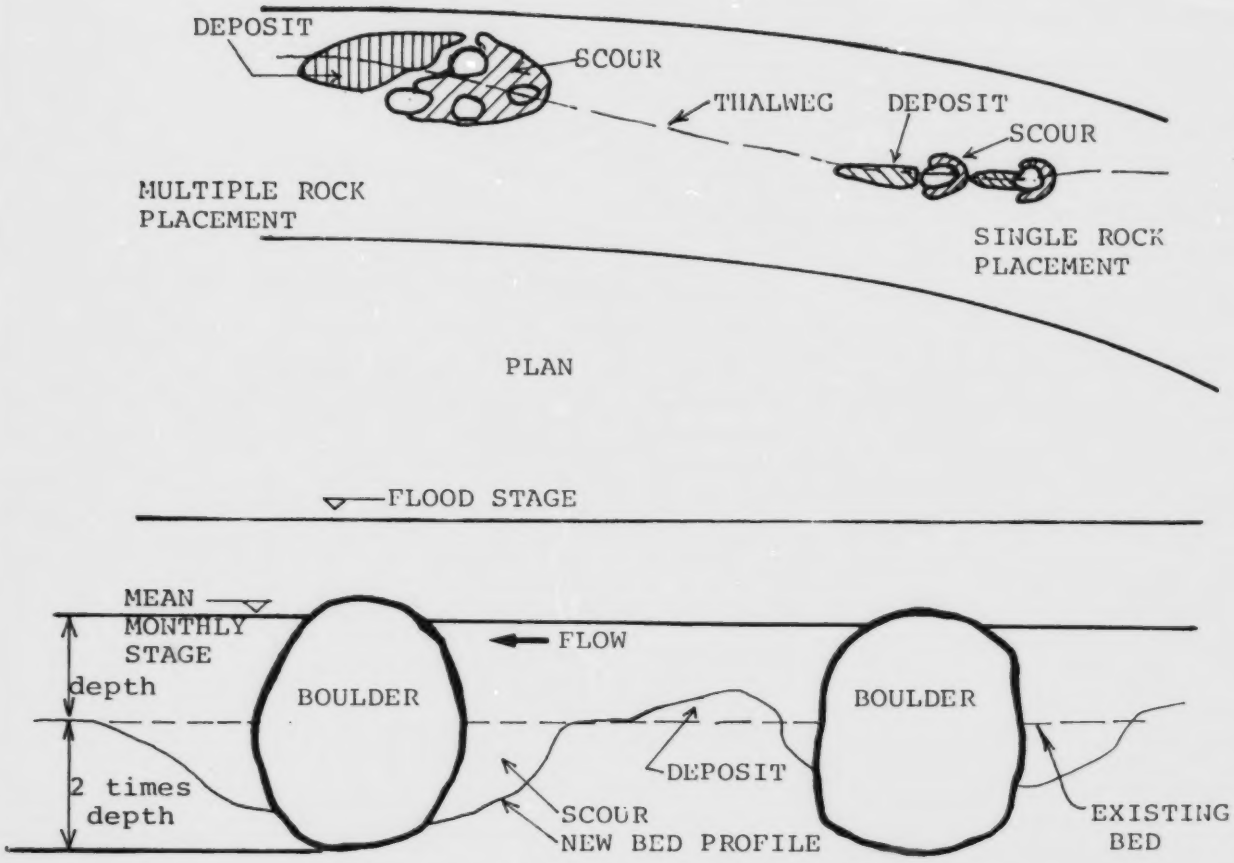


PLAN



SECTION A-A

FIGURE 6.2A ENCROACHMENT DETAIL



Notes: - Rock size at least 3 times the mean monthly flow depth
- Rock size also based on flood velocity

Minimum Size (mm)	Velocity (m/s)
450	3.0
800	4.0
1200	4.7

- Assumes an erodable bed

MITIGATION TYPE 3

FIGURE 6.3 BOULDER PLACEMENT

nating from one side to the other, will maintain the normal meander pattern (Fig.6.1). Due to the resultant concentrations of flow, pools at bends will become deeper, the banks will undercut more, and the resulting sand and silts will be deposited at the downstream end of the wing deflectors as point bars (Fig.6.1).

The following must be considered when installing a wing deflector to create pools and runs:

(1) Avoid installations in unstable floodplain or braided channel reaches of stream. In these areas structures may rapidly become ineffective or may add to existing instability.

(2) Locate the deflector well down the riffle to avoid impounding water upstream.

(3) Deflectors should form an angle with the stream bank of 45 degrees or less. Experience indicates that this improves their performance. The appropriate angle and length of wing will be specific to each site, and should generally conform to the natural meandering sequence of the stream.

(4) Boulders and/or rock-filled gabions are best suited for construction of wing deflectors. When individual rocks are used, the size of individual boulders will depend on the characteristics of the stream.

(5) Where the wing deflector connects to the river bank, the point of connection must be protected by rip-rap to above the flood level, so as to prevent the river from washing around the end of the deflector (Figure 6.1). Similarly, the bank opposite the deflector must also be protected to eliminate erosion that could be harmful to

fish habitat or streamside property.

(6) To minimize scour of the foundations of wing deflectors constructed with large rock, always use a minimum of two rows of rock, with the joints staggered. The second row should be set into the bottom of the river with the top slightly lower than the first row of rock, and the deflector should be triangular in shape.

(7) Where the stream bottom is composed of coarse material, pre-excavation of the intended pool or run will be required to speed up the natural erosion process and to ensure development of suitable habitat.

(8) The height of the wing deflector should be set so that at peak flows it is sufficiently submerged to pass logs and debris. If the deflector is set too high, severe bank and channel erosion could result.

6.1.3.2 Boulder Gardens

Grouping of boulders has been found to be the most effective method of increasing rearing habitat for juvenile salmonids. These installations consist of carefully placed boulders generally located at the upstream end of a very shallow pool or run area, and on the thalweg.

Three to five large, well-placed boulders, will create a stable run area within the riffle as well as provide cover for rearing salmonids (Figure 6.3). In large streams, boulder groupings can be repeated in a staggered arrangement down the length of a riffle, thus maximizing fish production. If correctly placed, the combined action of turbulent flow around the boulders and the transverse flow which develops on a bend will minimize bedload deposition downstream of the rock grouping. In some locations a short

wing deflector may be required in conjunction with the rock grouping to prevent gradual deposition of bedload material around the individual boulders.

These rock grouping installations require minimal maintenance because minor movements of individual rocks do not seriously reduce their effectiveness. However, a suitable spacing (2-3 m) must be maintained between the individual rocks to avoid accumulating debris and trapping bedload material. Where the stream substrate is coarse, some pockets form adjacent to the individual boulders.

6.1.3.3 Ledges and Pools

Water falling freely over a ledge tends to surge back and forth and scour beneath the ledge. The plunge pool formed is self-scouring and provides ideal conditions for fish to leap the obstacle.

Stone filled gabions and selected pieces of large rock can also be used to construct a submerged weir. In areas where rock is difficult to find, rejected pieces of concrete highway divider curb can be used. Because this device is submerged and only a small portion of the top of the weir will be visible through the water, precast concrete sections will not detract appreciably from the natural aesthetics of the stream.

Other devices have been used to develop pools within a stream, but some of them tend to create problems. For example, while pools may form below a low log or timber dam, silt and debris often deposit upstream of the dam, blanketing and destroying riffle areas which are important for spawning and aquatic insect production.

A good rule to follow when creating pools in a rock section

of stream is to improve and enlarge existing natural areas of pool development, rather than attempt to create an entirely new pool area which may conflict with the natural stream processes.

6.1.3.4 Rock Revetments

Rock or riprap revetments are a simple method of protecting stream banks from erosion. The outside curve of a meander can be protected with broken rock, to minimize bank erosion and improve fish cover. This often results in deepening of natural pools by increased bottom scour.

A riprap revetment should always be placed as jumbled pieces of rock with numerous angles and openings between each piece, and protruding into the current. It should never form a uniform wall. The openings between rocks and quiet back eddies formed by protruding rock faces provide juvenile fish with rearing sites and shelter from predators and stream freshets.

Rock revetments are almost always built in conjunction with other stream enhancement techniques. Wing deflectors and submerged weirs would not be effective if the opposite bank were not protected and stabilized with riprap (Figure 6.1). Rock revetments also minimize the risk of erosion damage to adjacent private land or to fish located upstream and downstream of the structure. Streambank protection and stabilization is an essential consideration in the design and installation of stream devices.

6.1.3.5 In-Stream Cover

Some streams are deficient in natural cover. Bushes and shrubs, reaching over and into the water, provide excellent hiding areas for juvenile salmonids. Similarly, dead trees,

bushes and branches which fall into the water can also provide stable cover. Falling leaves provide a food source for invertebrates and hence fish. From these shelter areas, fish can safely dart into the current to obtain drifting food. They also protect fish from conflict with other individual fish. Every effort should be made to preserve the beneficial aspects of this type of cover. However, excess cover including accumulations of logging or windblown debris, can reduce salmonid production.

Several simple methods and devices are available to enhance this aspect of the fishes environment. Trees and large branches can be anchored to the stream bank to duplicate natural cover.

The construction and installation of cover devices in a stream should ensure that the cover is incorporated with other stream enhancement devices, such as rock clusters, overhangs, and revetments opposite deflector wings.

6.2 Nutrient Enrichment

A review of the literature pertinent to nutrient enrichment methodologies was commissioned by our team in order to provide a comprehensive overview of current approaches, both theoretical and pragmatic, to this subject (Appendix C). The reader is referred to this literature review for the appropriate references. The review indicates that there are significant possibilities for the employment of such strategies, although more detailed, on-site experimental evaluations will be required.

Alberta Environment (1987b) provided a feasibility study of nutrient enrichment related to sport fish production in the Castle and Oldman Rivers upstream of the dam. The following section incorporates the two above referenced studies. Fish

production in any river system can be limited and/or constrained by abiotic or biotic factors. The major abiotic factors are (i) the availability of suitable habitat to satisfy all the crucial life stages of a fish species, (ii) the water temperature regime, and (iii) the flow regime. In fact, the former two factors are themselves products of the flow regime. Habitat is usually defined in terms of substrates, stream depth and velocity, all intimately linked to the flow regime, as is the water temperature regime. The major biotic factors affecting fish production are (i) the food supply, and (ii) the water quality or nutrient status.

Sport fish production in the Oldman River Basin, above the dam site, is much higher in the Crowsnest River than the Castle or Oldman North Fork Rivers. This difference is presumably a result of a combination of abiotic and biotic limiting conditions. From the available habitat surveys on the lower portions of the three main tributaries it appears that there is, or at least was at the time of survey, suitable habitat in the Castle and Oldman North Fork Rivers that was not being utilized to full potential. This usually leads to a conclusion that biotic factors, such as inadequate food supply, might be responsible for underutilization in those reaches.

There are major differences between the rivers in terms of flow regime. Although the Oldman River Basin, measured at Waldron's Corner, is almost twice as big as the Castle Basin (near Beaver Mines), i.e. 1440 km^2 to 826 km^2, the mean monthly flows for June (which is usually the highest flow month) do not reflect basin size (54 cms Oldman to 65.5 cms for Castle). The same values for the Crowsnest are 402 km^2 and 16.7 cms. However, the one element of the flow regime that has a strong influence on habitat availability and stability is the extreme flow event which can destroy or create habitat. For these three rivers the most

representative indicator is the maximum daily discharge (Castle - 535 cms; Oldman - 337 cms; Crowsnest - 60 cms) and these values show the erratic nature of the Castle River flow regime. These recorded values are very similar to the calculated flood frequency estimates for a 25 year return period flood reported by Northwest Hydraulics (NHCL, 1987) in a study for Alberta Environment (Castle - 520 cms; Oldman - 350 cms; Crowsnest - 102 cms). Thus, since fish habitat is closely related to flow regime, it is likely that some degree of abiotic constraint does exist in the Castle and Oldman North Fork Rivers at least in comparison to the Crowsnest River. It is possible that habitat on the former two rivers is less stable. However, this does not sufficiently explain the under-utilization of habitat found in the surveys of 1985/86. Therefore, it is possible that fish utilization is being limited by food supply.

Rainbow trout usually feed on various invertebrates on the stream bottom, but may also feed opportunistically at the surface on emergent or egg laying (ovipositing) insects. Mountain whitefish are mainly bottom feeders, consuming invertebrates, molluscs and fish (Scott and Crossman, 1973). Aquatic invertebrates constitute important food for both of the main sports fish in the upper Oldman Basin. The biomass of aquatic invertebrates is dependent on two major energy sources:

(i) autochthonous - derived from photosynthetic activity through algae;

(ii) allochthonous - organic material imported into the system, usually in the form of detritus, providing between 50 and 99% of all available food energy to invertebrates and lower trophic forms.

There is usually a close relationship between the distribution and abundance of benthic organisms and the distribution of plant detritus. On larger rivers allochthonous energy tends to decrease due to lack of materials which are available from the banks. However, small streams draining forested watersheds rely on their major energy supply from the import of organic matter serviced from the terrestrial systems through which they flow.

On the basis of phosphorous concentration, the Oldman and Castle Rivers may be considered to be oligotrophic, while the Crowsnest River appears to be mesotrophic. The higher phosphorous levels in the Crowsnest River are thought to result from municipal inputs from the Crowsnest Pass communities. In aquatic systems, because of the rapid uptake and entrapment of phosphorous by plants, phosphorus is often considered to be the major factor in limiting productivity. Observations on foothills streams in Alberta appear to suggest that the availability of dissolved nitrogen may also be limited. The abundance of blue-green nitrogen fixing algae such as Nostoc indicate low nitrogen supply. However, the shortfall in nitrate in such systems is more than made up for by the blue-green nitrogen fixers. Also, the addition of nitrates to a stream can lead to increased algal growth and a resulting temporal sag in oxygen levels within certain reaches.

Two feasible methodologies for artificial fertilization are available for the rivers of the upper Oldman River Basin:

(i) introduction of nutrient solutions at some point above the planned reservoir;

(ii) in-situ river fertilization using decaying organic matter such as silage, alfalfa, leaves.

The results of nutrient additions in solution form in southern Alberta have been reported from North Drywood Creek. In this case, treated waters from the Shell Waterton gas plant caused eutrophication of the creek downstream of the effluent release. This caused significant algal blooms and substantial increases in benthic invertebrate biomass, but also made resident trout slimy and unpleasant tasting. It transpired that too much phosphorous was being used in the treatment ponds at Waterton and that the excess was entering the river (Dr. R. Crowther, personnal communication). This was reduced and the stream below the effluent site recovered over a two year period. Thus, it appears that the addition of phosphorous to streams such as North Drywood Creek will cause substantial increases in benthic algae production, which in turn changes the trophic status and would cause a deterioration of sport fisheries rather than an enhancement.

The main type of deritus in the basin above the dam site (particularly the Castle and Oldman North Fork Rivers) at present is coniferous, which breaks down very slowly under bacterial and fungal action. The long conditioning period, and slow breakdown, of coniferous detritus could be caused by the presence of anti-fungal and bacterial chemicals. The relatively low water temperatures in this region could further extend the conditioning period. Also, the lack of any substantial deciduous input could further cause these streams to be unproductive for benthic invertebrates and hence fish.

The emplacement of decaying organic matter in the streams should not only increase benthic standing stocks but also produce an increase in stream insect drift, which would be advantageous to trout. The method could employ a mesh envelope across the full stream width, fixed to the bed with stakes at the downstream side of a riffle. A fixed emplacement would allow reuse. Into the envelope would be placed

decaying organic matter such as silage or alfalfa, which would be colonized by naturally occurring aquatic bacteria and fungi which would then produce a palatable food source for benthic invertebrates and increase secondary benthic productivity. The source for this organic material would be local farmers, which together with a re-usable envelope, should make the enhancement procedure cost effective. The use of grain, commercial fertilizer, or deciduous leaves will probably not be as cost effective.

This technique has been shown to be viable on a smaller scale, and could prove of value on the Castle and Oldman North Fork Rivers. It is not thought that this type of fertilization should be carried out on the Crowsnest River because of existing high phosporous loadings from municipal wastes. Further enrichment could push the Crowsnest into an eutrophic classification, making it more productive to coarse fish species to the detriment of the sport fish currently there. This problem could also result from the use of liquid nutrients (phosphates) on either the Castle or Oldman North Fork River.

6.3 Other Mitigation Techniques

Under certain adverse conditions related to flow regime, such as extreme water level fluctuations, instability of substrate, and water temperature extremes at certain seasons, there may be geographical or temporal limitations to the use of a waterbody for a sport fishery. A stream may be suitable for rearing and adult life stages of a species, but have no possible spawning sites. If a sport fishery is to be considered for a stream or waterbody with these limitations then it may be necessary to create habitat or provide a means of bypassing a life stage necessity. Several of these possible options may come into play in mitigating for the Oldman Dam.

The dam will be barrier to upstream migration of both rainbow trout and mountain whitefish to existing spawning sites. Although it is likely that sufficient mountain whitefish spawning areas will be found downstream under the regulated flow regime, it might be necessary to create rainbow trout spawning areas or to provide a post-spawning stock. One possibility is the creation of side channels with suitable substrate that are linked with the main flow, but protected from high flow events which would disturb or destroy the spawning sites. Because of the requirement for flood protection, this mitigation could be quite costly. Also, because of the "homing" nature of rainbow trout and water temperature sensitivity, the potential effectiveness of such spawning channels would have to be evaluated before implementation. To overcome the need for the creation of spawning areas, a hatchery could be constructed, or accessed, which would allow spawning outside of the channel flow, and provide stocking of the river with emergent fry. Both of these techniques related to rainbow trout spawning are predicated on the need/advisability of a rainbow trout fishery below the dam.

If a reservoir fishery is to occur it may be necessary to create an impoundment environment separated from the anticipated drawdown zone of the main reservoir. A possible solution is an offstream impoundment in one of the tributary channels or coulees. A barrier would have to be constructed such that the side impoundment water level would be stabilized and separated from the reservoir. At full supply level the side impoundment could be filled from the reservoir. Stocking of the side impoundment with sport fish would probably be required if the dominant species of fish is not to become coarse or forage species. Construction of any side dam would be excessively expensive, especially on an entrenched coulee. Once again, the desirability of such a fishery, especially with respect to anticipated fishery

benefits from other enhancement techniques, would have to be evaluated. However, we suggest that it would be much more efficient to expend equivalent funds on mitigation efforts in upstream areas.

6.4 Habitat Mitigation: A Prescriptive Approach

6.4.1 General Approach

Early in our discussions with government local officials, it became clear that much of the interest for fisheries mitigation was directed to the upstream, tributary areas. We also recognized that funds are not unlimited and that pragmatic choices which take into consideration cost-effectiveness will have to be made soon. In addition to these substantial obstacles, there was little local support for, or interest in, a reservoir fishery to compensate for lost riverine fish and habitat.

6.4.2 Upstream of FSL

A summary of the instream habitat mitigation techniques deemed suitable in our analysis is presented in Table 6.1. Habitat classification R3 and R3/BG were not divided into slow and fast categories in the RL&L data base. An assumption of this portion of our study is that habitat classification R3 is equally divided into habitat with slow and fast flowing water. We further note that a conversion from habitat classification R3 to R1 or RF will require a reduction in channel width, with a corresponding reduction in habitat area. We have assumed that the above noted conversion would reduce the ultimate habitat area by 50%. That is, it would be necessary to convert twice as much (in areal terms) habitat classified as R3, to R1 or RF to arrive at the same area of initial habitat classified as R3.

Specific mitigation works required to replace habitat lost due to inundation by the reservoir are presented in Table 6.2 to Table 6.4 for the Castle, Crowsnest, and Oldman North Fork Rivers.

TABLE 6.1
MITIGATION TECHNIQUES

IMPROVED HABITAT	ORIGINAL HABITAT	TECHNIQUE
RA/BG	RA	ADDITION OF BOULDERS
R2/BG	R2	ADDITION OF BOULDERS
RF/BG	RF	ADDITION OF BOULDERS
R1 & P1 & RF/BG	R3	FOR FAST SHALLOW R3, NARROW THE CHANNEL AND PROVIDE LEDGES AND MEANDERS TO REDUCE CHANNEL SLOPE AND DEEPEN THE WATER. INSTALL BANK OVERHANG ON POOLS AT BENDS (c/f.4.3.1)
RF/BG & RA & RF	R3	FOR SLOW SHALLOW R3, NARROW THE CHANNEL AND PROVIDE RIFFLES

TABLE 6.2
MITIGATIVE WORKS - CASTLE RIVER

SPECIES	LIFESTAGE	PREFERRED HABITAT TYPE	LOST AREA(sm)	MITIGATION TECHNIQUE(1)	HABITAT AREA(sm)
RAINBOW TROUT	JUVENILE	RF	27125	2	106,416
		RA/BG	30263	3A	174,783
			57388		281,199
	ADULT	R1	66063	1	106,416
		P1	5(2)	1	5
		R2/BG	12600	3B	171,164
			78663		277,580
MOUNTAIN WHITEFISH	JUVENILE	RF	27125	2	(4)
		R3/BG	1600		
		R3	33300	(1+2)	-425,664(3)(5)
			62025		-425,664
	ADULT	RA/BG	30263	3A	(4)
		R2/BG	12600	3B	(4)
		R1	66063	1	106,416
		P1	5(2)	1	5
		RA	122764		
		R2	86513		
			318203		106,416

NOTES:

(1) REFERS TO FIGURES 6.1, 6.2, 6.3
(2) PONDS (P1) REFER TO NUMBER OF PONDS, NOT POND AREAS
(3) R3 HABITAT IS CONVERTED TO RF, R1, AND P1 HABITAT WITH 2 UNITS OF R3 HABITAT REQUIRED TO PRODUCE 1 UNIT OF RF, R1, AND P1 HABITAT. IN OUR VIEW THIS REPRESENTS A GENEROUS ALLOWANCE FOR ACTUAL HABITAT LOST.
(4) UPGRADING WOULD BE FROM USE RATING 4 TO 5 WHICH IS NOT CONSIDERED AS VALID MITIGATION
(5) THE ACTUAL LOSS OF HABITAT (PERCEIVED VS. ACTUAL) WILL BE BETTER KNOWN ONCE ONGOING FIELD STUDIES (1987) ARE COMPLETE.

TABLE 6.3
MITIGATIVE WORKS - CROWSNEST RIVER

SPECIES	LIFESTAGE	PREFERRED HABITAT TYPE	LOST AREA(sm)	MITIGATION TECHNIQUE(1)	HABITAT AREA(sm)
BROWN TROUT	JUVENILE	RA/BG	8148	3A	8,300
		R1	18075	1	9,399
		R2/BG	2875	3B	26,438
			29098		44,137
	ADULT	R1	18075	1	9,399
		P1	3(2)	1	3
		R2/BG	2875	3B	26,438
			20950		35,837
RAINBOW TROUT	JUVENILE	RF/BG	8910	3C	(4)
		RA/BG	8148	3A	28,246
		RF	55830	2	76,825
			72888		105,071
	ADULT	R1	18075	1	76,825
		P1	3(2)	1	3
		R2/BG	2875	3B	105,538
			20950		182,363
MOUNTAIN WHITEFISH	JUVENILE	RF	55830		
		R3/BG	1705	3B	(4)
		R3	88790	(1+2)	-307,298(3)
		RF/BG	8910	3C	(4)
			155235		-307,298
	ADULT	RA/BG	8148	3A	(4)
		R2/BG	2875	3B	(4)
		R1	18075	1	76,825
		P1	3(2)	1	3
		RA	16680		
		R2	17935	3B	(4)
			63713		76,825

NOTES:
(1) REFERS TO FIGURES 6.1, 6.2, 6.3
(2) PONDS (P1) REFER TO NUMBER OF PONDS, NOT POND AREAS
(3) R3 HABITAT IS CONVERTED TO RF, R1, AND P1 HABITAT WITH 2 UNITS OF R3 HABITAT REQUIRED TO PRODUCE 1 UNIT OF RF, R1, AND P1 HABITAT. IN OUR VIEW THIS REPRESENTS A GENEROUS ALLOWANCE FOR ACTUAL HABITAT LOST.
(4) UPGRADING WOULD BE FROM USE RATING 4 TO 5 WHICH IS NOT CONSIDERED AS VALID MITIGATION
(5) THE ACTUAL LOSS OF HABITAT (PERCEIVED VS. ACTUAL) WILL BE BETTER KNOWN ONCE ONGOING FIELD STUDIES (1987) ARE COMPLETE

TABLE 6.4
MITIGATIVE WORKS - OLDMAN RIVER NORTH FORK

SPECIES	LIFESTAGE	PREFERRED HABITAT TYPE	LOST AREA(sm)	MITIGATION TECHNIQUE(1)	HABITAT AREA(sm)
RAINBOW TROUT	JUVENILE	RF	56663	2	119,626
		RA/BG	9225	3A	61,302
			65888		180,928
	ADULT	R1	34450	1	119,626
		P1	2(2)	1	2
		R2/BG	5850	3B	105,186
			40300		224,812
MOUNTAIN WHITEFISH	JUVENILE	RF	56663	2	(4)
		R3	7863	(1+2)	-478,504(3)
			64526		-478,504
	ADULT	RA/BG	9225	3A	(4)
		R2/BG	5850	3B	(4)
		R1	34450	1	119,626
		P1	2(2)	1	2
		RA	32275		
		R2	27500	3B	(4)
			109300		119,626

NOTES:
(1) REFERS TO FIGURES 6.1, 6.2, 6.3
(2) PONDS (P1) REFER TO NUMBER OF PONDS, NOT POND AREAS
(3) R3 HABITAT IS CONVERTED TO RF, R1, AND P1 HABITAT WITH 2 UNITS OF R3 HABITAT REQUIRED TO PRODUCE 1 UNIT OF RF, R1, AND P1 HABITAT. IN OUR VIEW THIS REPRESENTS A GENEROUS ALLOWANCE FOR ACTUAL HABITAT LOST.
(4) UPGRADING WOULD BE FROM USE RATING 4 TO 5 WHICH IS NOT CONSIDERED AS VALID MITIGATION
(5) THE ACTUAL LOSS OF HABITAT (PERCEIVED VS. ACTUAL) WILL BE BETTER KNOWN ONCE ONGOING FIELD STUDIES (1987) ARE COMPLETE.

No credit was given for habitat mitigation which would raise the habitat from a use rating 4 to use rating 5. This is not to say this is not a desirable habitat upgrading. However, to do so in this study would result in a credit for mitigation of habitat lost below FSL by utilizing already good to excellent habitat upstream of FSL for the species in question. This is not in accordance with our stated objectives of mitigating valuable habitat lost (use ratings 4 and 5) with equal habitat above FSL in addition to already existing valuable habitat above FSL.

Table 6.5 presents a summary of the habitat lost due to inundation by the Oldman River Dam reservoir, and the potential habitat gain above reservoir FSL to mitigate the loss.

TABLE 6.5
HABITAT SUMMARY

SPECIES	LIFESTAGE	HABITAT LOST (sm)(1)	MITIGATIVE HABITAT GAIN (sm)
RAINBOW TROUT	JUVENILE	226,865	567,198
	ADULT	224,676	684,755
BROWN TROUT	JUVENILE	29,098	44,137
	ADULT	20,950	35,837
MOUNTAIN WHITEFISH	JUVENILE	413,574	-1,211,466(2)
	ADULT	979,243	302,867

NOTES: (1) INCLUDES LOSS ON OLDMAN RIVER MAIN STEM
(2) HABITAT LOST TO TROUT MITIGATION

It is apparent from Table 6.5 that the lost habitat for rainbow and brown trout can, in theory, be mitigated above FSL within the surveyed database. As rainbow and brown trout were the priority species to be mitigated, their mitigation is presented in Table 6.5 at the expense of mountain whitefish. However, no great losses in the

mountain whitefish population are expected as indicated by the existing literature. This is because it is currently expected that the mountain whitefish will be able to co-utilize the mitigated habitat which is developed. Niche stratification for the fish species should allow co-habitation.

Another factor to consider is that mitigation for adult lifestage will also permit juvenile rearing in shallower zones, and through co-habitation mountain whitefish juveniles should benefit from trout mitigation techniques.

Given the predicted, extensive losses of juvenile mountain whitefish habitat, future consideration of possible mitigative techniques to leave unchanged a portion of the habitat for this species may be examined. Studies are currently being planned to locate and evaluate further spawning areas in the basin for this species. These data may subsequently be factored into the final mitigation plan for the basin.

This mitigation of habitat ignores access limitations to the potentially upgraded mitigative habitat. We believe a more pragmatic approach to habitat mitigation upstream of FSL is to utilize the entire Oldman River system upstream of FSL. An aerial reconnaissance was undertaken, by helicopter, by our study team, accompanied by representatives of Alberta Environment, and Alberta Fish and Wildlife, on June 19, 1987. During the aerial reconnaissance specific potential mitigation sites were identified for each of the Castle, Crowsnest, and Oldman North Fork Rivers. The results of the aerial reconnaissance are certainly not definitive, but do present site specific areas which may be examined further as to specific mitigative works required and their design. At that time the mitigative area resulting from each selected site specific area may be determined and, by comparison with

the required mitigative areas to be obtained (Table 6.5), an assessment of further mitigative works required (if any) may be made.

6.4.2.1 Castle River

In general, the Castle River is quite variable in terms of physical habitat, and there are no significant reaches (greater than 200 m) of consistent habitat type. Photographic documentation of the River is presented in Appendix B. The following site-specific mitigative projects have been identified (Figure 6.4).

A - Good access with potential for type 2 mitigation works
B - Castle Canyon. Existing prime habitat with limited access. Potential exists for extending access road from existing farm road at downstream end of canyon.
C - Existing recreational area with good access. Potential for mitigation type 3.

6.4.2.2 Crowsnest River

In general, the Crowsnest River has a large degree of man - made channelization resulting in large reaches of consistent type habitat. There is excellent access along almost the entire reach of the river above Lundbreck Falls. Downstream of the Falls there is very limited access with the exception of the Falls site itself.

Photographic documentation of the river is presented in Appendix B. The following site specific mitigative projects have been identified (Figure 6.5).

A - Upstream of Lundbreck Falls; likely requires mitigation type 3B, and possible some mitigation type 2.

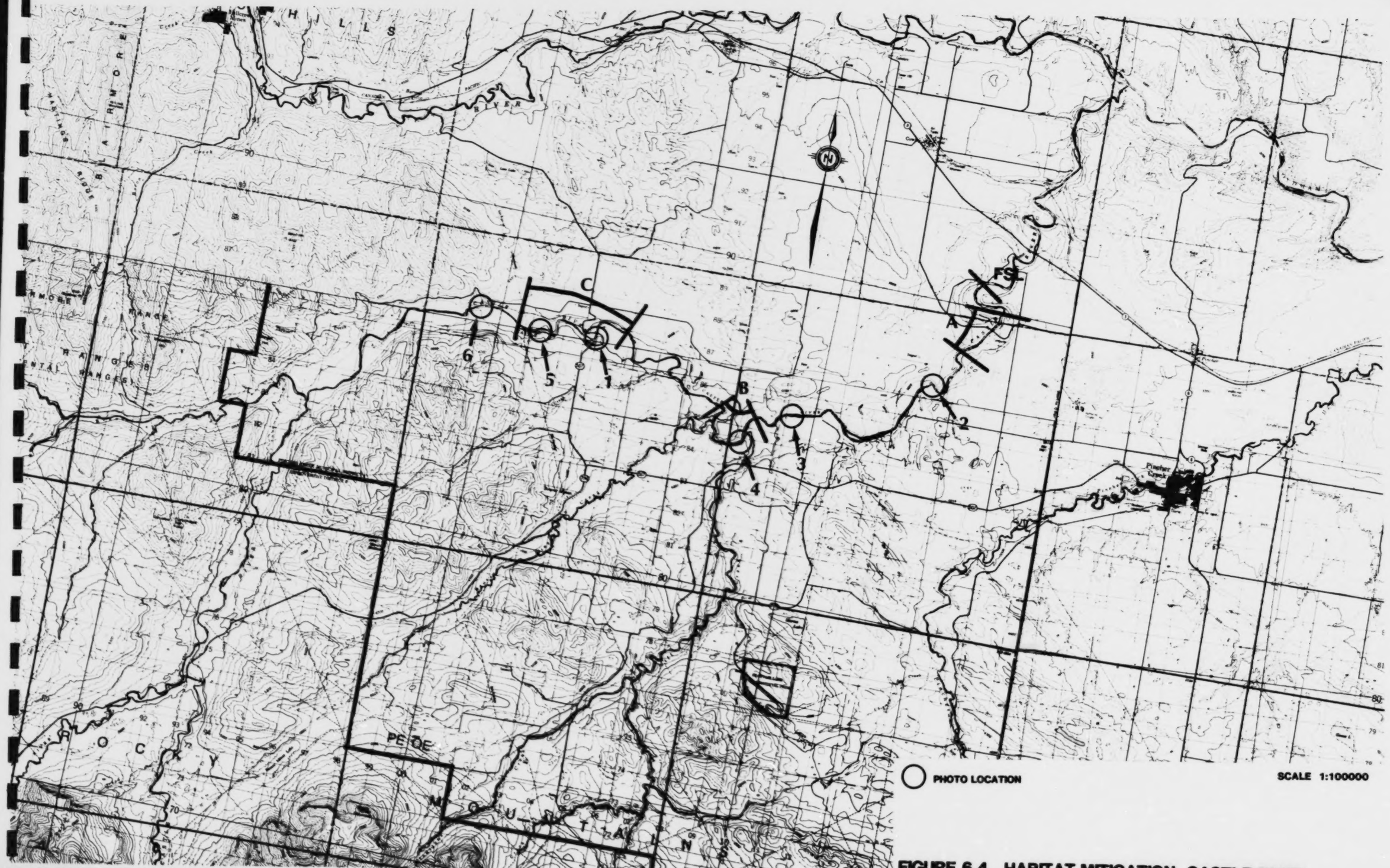


FIGURE 6.4 HABITAT MITIGATION CASTLE RIVER

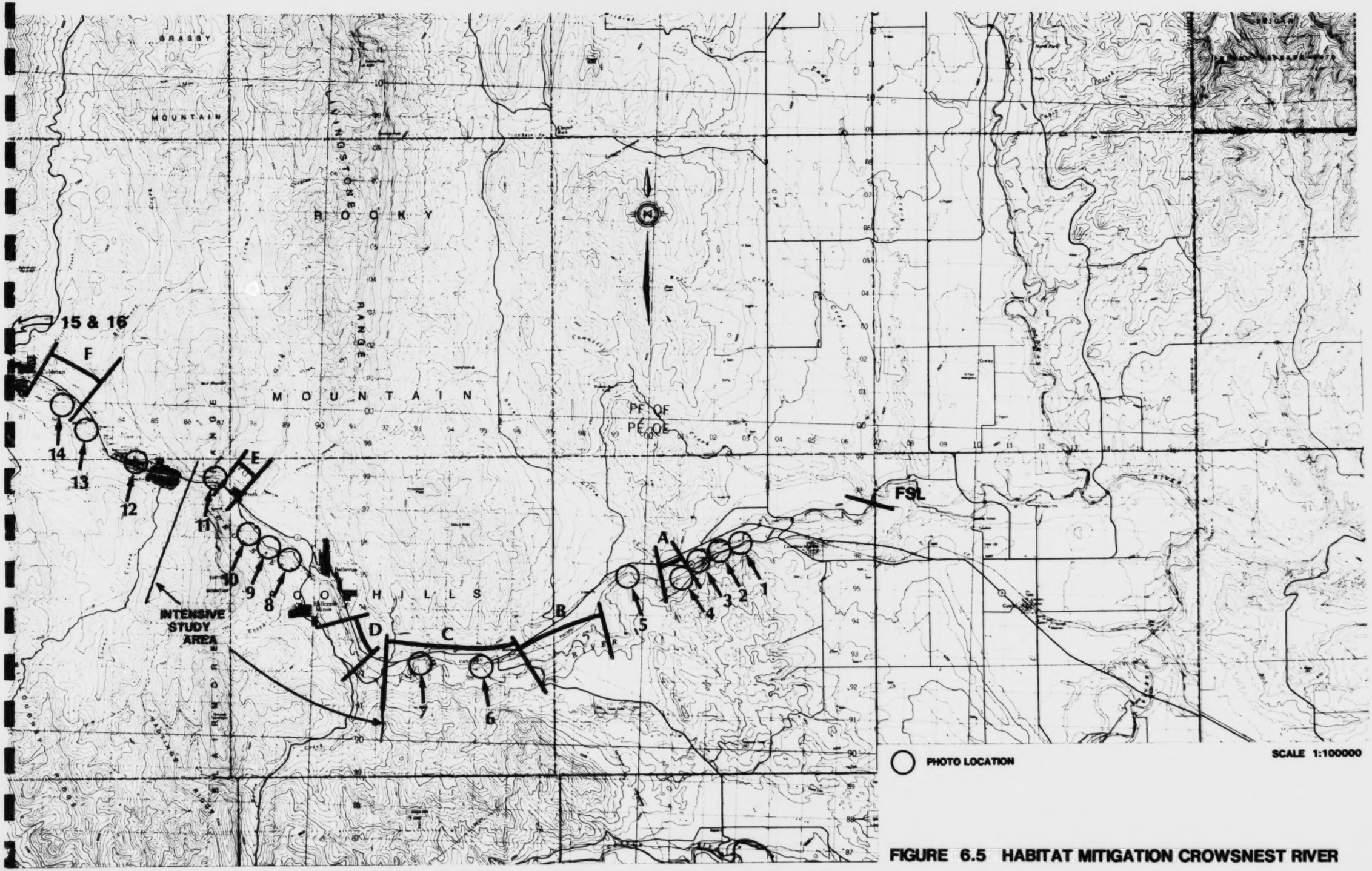


FIGURE 6.5 HABITAT MITIGATION CROWSNEST RIVER

B - downstream of Burmis Bridge with excellent access; requires bank stabilization through mitigation type 1, and possible some reaches of mitigation type 3.

C - potential applications for all mitigation types if existing habitat is surveyed to use rating 3 or less.

D - good access, requires type 1 mitigation

E - good access; stable banks with no instream cover. Requires type 1 mitigation, and possibly mitigation type 3.

F - channelized section below Coleman (Figure 6.5a, Figure 6.5b). Old stream bed adjacent to channelized portion. This is a unique situation. Potential exists to construct a control structure to divert low flows down the old stream channel, and utilize the channelized section for flood flows. This will produce 2-3 km of useable excellent fisheries habitat. Potential for mitigation type 3 in the channelized river reach.

A section of the river between Blairmore and Burmis has been identified as an Intensive Study Area (Figure 6.5). The first mitigation projects are located within this reach.

6.4.2.3 Oldman River - North Fork

In general, from the confluence with the Castle River to the North Fork Bridge, there is very limited access to the river, greatly restricting the potential for physical mitigative works. Compared to the Castle River, the habitat is quite consistent; generally lacking in-stream and bank cover. Photographic documentation of the river is presented

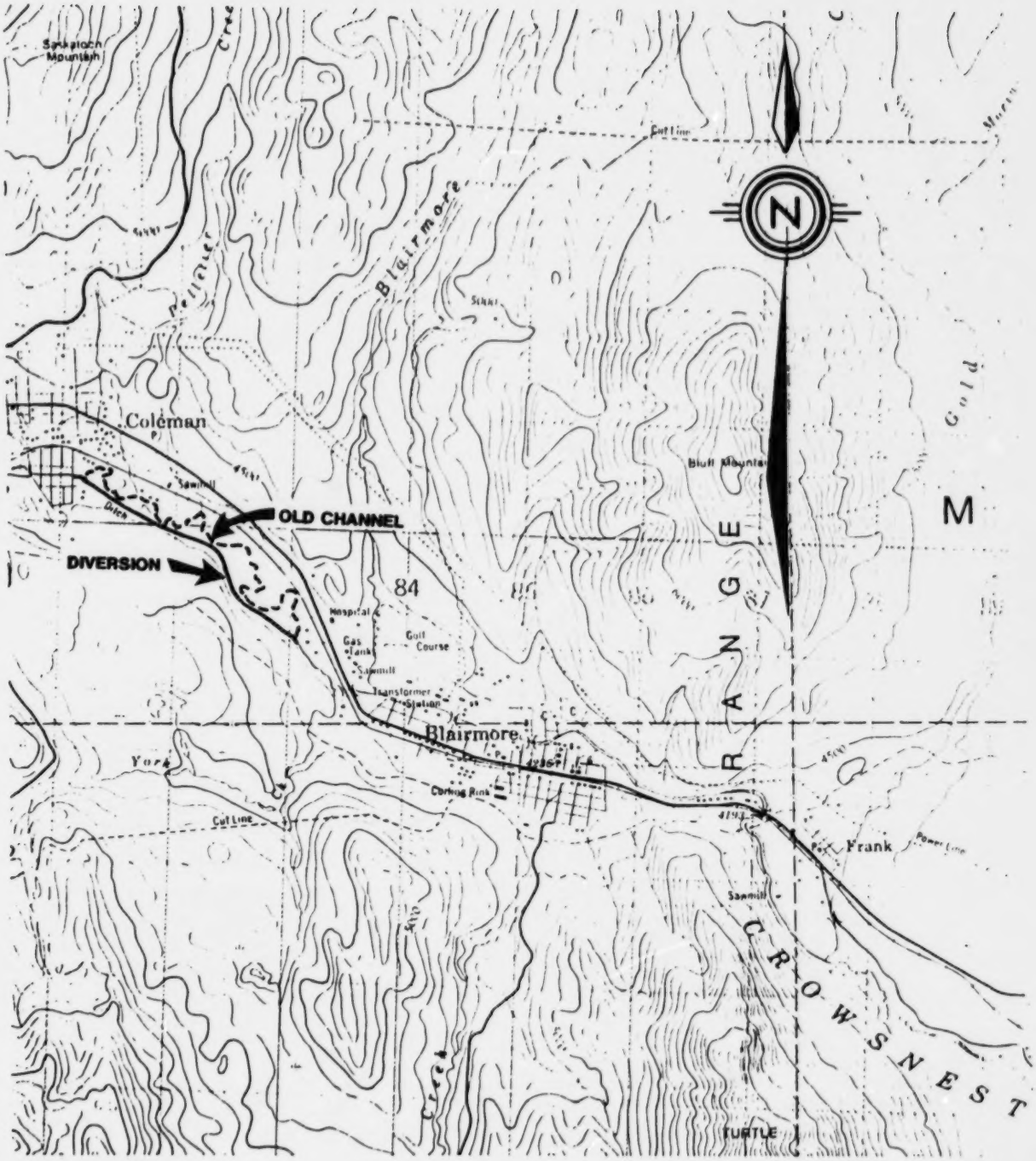


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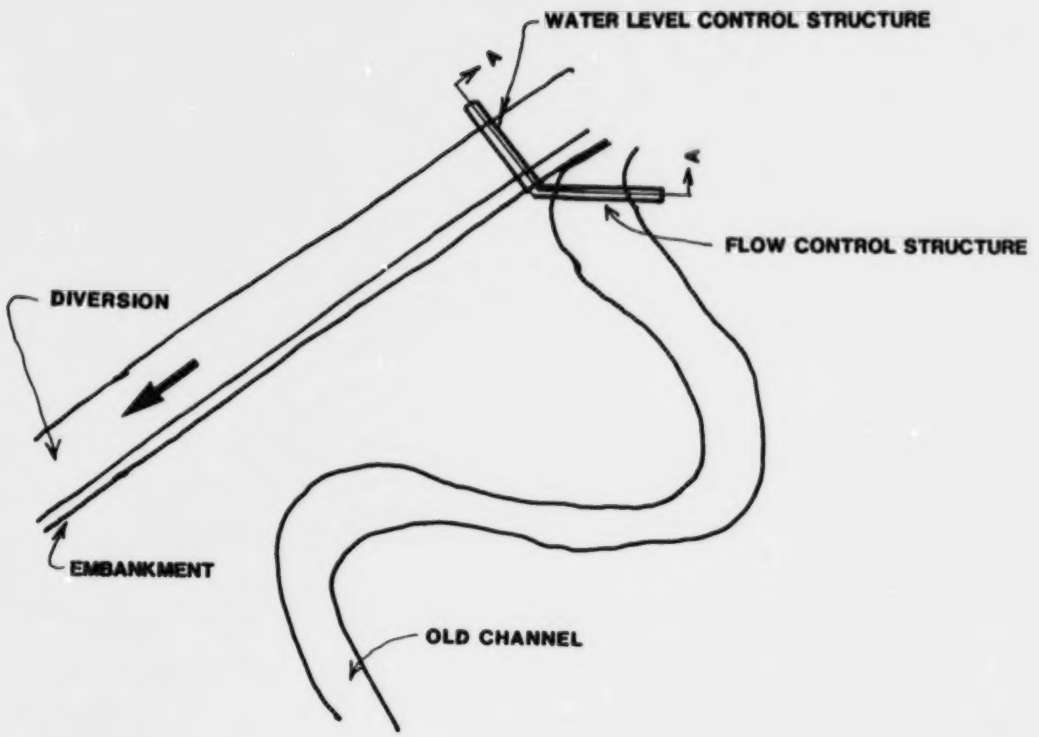
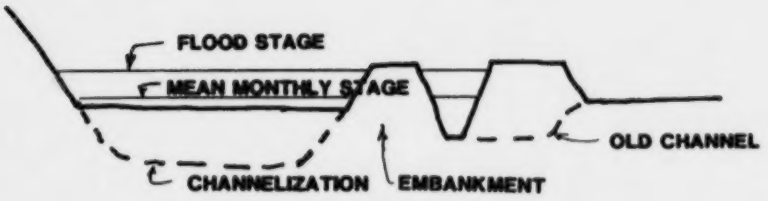
FIGURE 6.5A COLEMAN CHANNELIZATION



PLAN



SECTION A-A

FIGURE 6.5B COLEMAN CHANNELIZATION DETAIL

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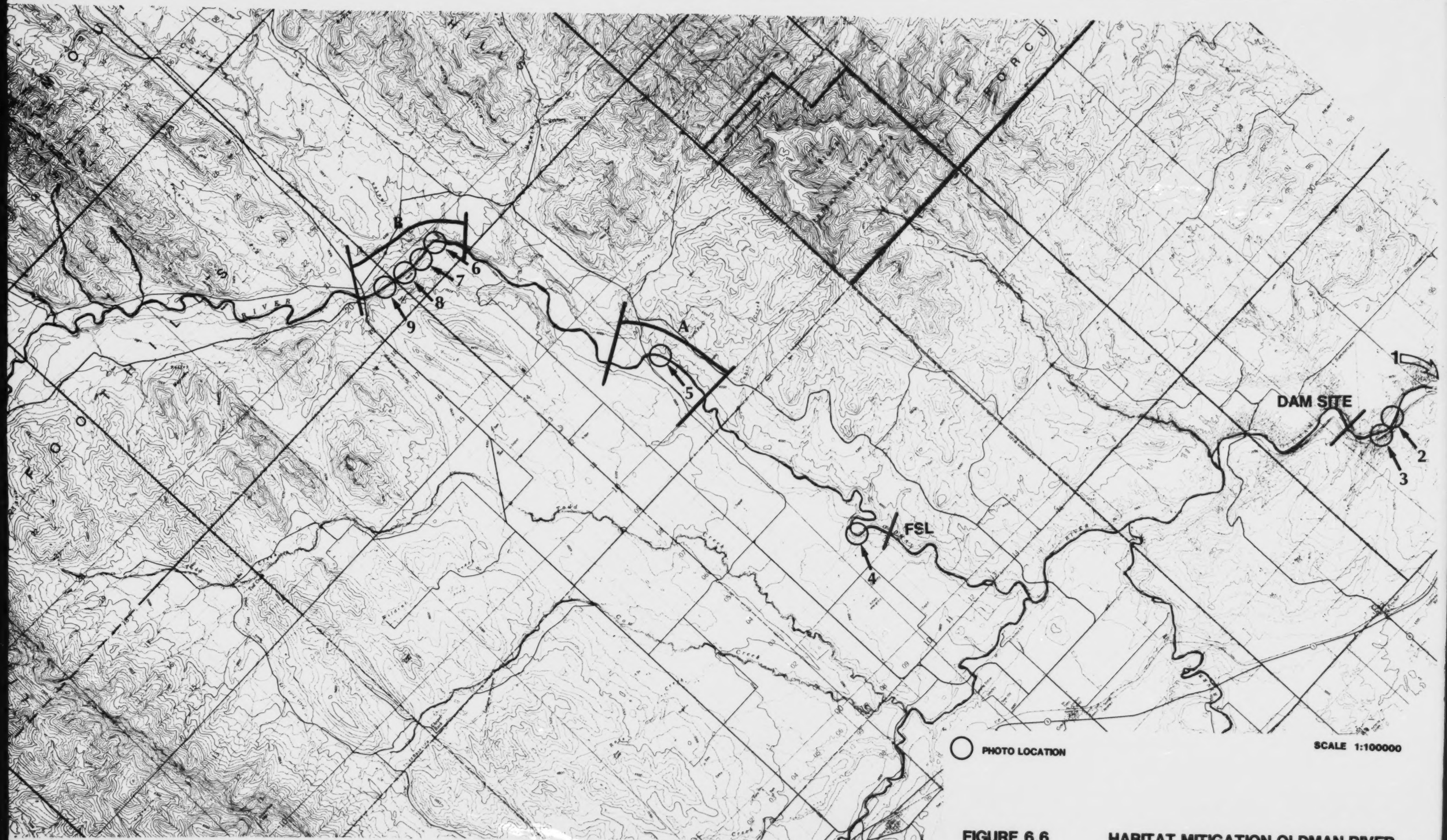

FIGURE 6.6 HABITAT MITIGATION OLDMAN RIVER

in Appendix B. The following site specific mitigative projects have been identified (Figure 6.6).

A - North Fork Bridge. Excellent access. Potential for mitigation type 2 and mitigation type 3.

B - Highway 22 Bridge. Excellent access from access roads built by Alberta Fish and Wildlife. Upstream of the Fish and Wildlife access road there is potential for mitigation type 2 and mitigation type 3.

6.4.2.4 Access Considerations

The Municipalities of Crowsnest Pass and Pincher Creek have developed access surveys and inventories for the region. A full examination of access facilities (parking) will have to be incorporated with the final fisheries mitigation plan, once engineering and biological evaluations have been completed.

6.4.3 The Reservoir

Although the preferred mitigation for lost riverine sport fishery habitat is to replace with riverine habitat by mitigative techniques elsewhere in the Oldman Basin, the existence of a large waterbody (2420 ha at FSL) would require some consideration of the potential for eventual fishery utilization. RL&L (1986) prepared a summary document that outlines expected reservoir fish populations and discusses the viability of a reservoir fishery. Alberta Environment (1987c) in a draft document assessing fishery impact from the Oldman River Dam also discusses the potential for, and problems relating to, a reservoir fishery.

The reservoir has been described elsewhere in this report. It is expected to be a deep (68 m maximum, and 21 m mean

depth), cool waterbody (summer maximum water temperature around 14°C), with weak summer thermal stratification of limited duration due to the bottom withdrawal regime (hypolimnetic). Significant shoreline erosion is likely in the reservoir below the Castle River confluence. The reservoir will generally be low in nutrients, except for the likely trophic upsurge expected during the initial years following reservoir filling. The reservoir will probably attain an upper oligotrophic to lower mesotrophic productivity range. Long-term biotic productivity will be constrained since the summer drawdown of water level, relatively high turbidity levels, and possible wave action will severely restrict the establishment of aquatic macrophytes and benthic invertebrates in the littoral and sub-littoral zones. It is expected that the three arms of the reservoir will be more productive than the mainstream section, and that the Crowsnest River arm will be the most productive area of the reservoir.

Under natural recruitment conditions the fish species inhabiting the reservoir will be limited to those species currently in the reservoir area. The fish fauna in the Oldman Reservoir is expected to be dominated by longnose and white suckers, with mountain whitefish constituting the major sport fish species (RL&L, 1986c). There is the possibility of limited presence of rainbow and brown trout because they are established on the inflowing streams. The Crowsnest River area may support larger sportfish stocks because of the influence of the Crowsnest River. Several forage species are expected to become established in the Oldman River Reservoir (longnose dace, lake chub, trout perch, and spoonhead sculpin). Lake whitefish have been reported in the area but are not expected to become a viable natural reservoir population.

Generally, southern Alberta reservoirs do not support

productive sport fisheries without a committment to large scale and continual stocking programs (RL&L, 1986,c). Therefore, if a sport fishery is to be developed on the Oldman River Reservoir this must be the main mitigative option to be considered. The species to be stocked would depend on angling desirability and potential viability for life-cycle survival in the reservoir. Spawning sites for rainbow and brown trout should exist above the reservoir in the inflowing rivers, particularly the Crowsnest River, but there could be problems from increased competition for food and spawning habitat. Also, there is the potential for dilution of wild genetic stock in the trout population from interbreeding between wild and hatchery fish. The use of lake trout for stocking would require that available spawning existed, or were created, at the upstream end of the reservoir.

Any stocking program would have to consider a number of problems presented by the anticipated aquatic environment. The low water temperature would be a severe limiting factor on growth and productivity. The high turbidity expected in some zones of the reservoir would also contribute to low productivity. However, the major limiting factor of the Oldman River Reservoir will be the degree of water level drawdown. Figure 5.1 shows the long term situation at full irrigation, based upon data provided by Alberta Environment, Planning Division (D. Hagerman, personal communication, June 9, 1987). The anticipated drawdown from June to October is approximately 10 m under mean conditions, and could exceed 20 m under extreme conditions. Even at the mean level there would be severe effects upon littoral food sources, and the drawdown would have a disruptive effect on fish species inhabiting the shallows. The extent of the drawdown would also have detrimental effects upon the recreational/angling desirability of the reservoir, since the water level will trend downwards throughout the entire summer season, expos-

ing either muddy flats, beaches or barren areas. It has been suggested that vegetation could be planted in the anticipated drawdown zone, but reservations have been expressed since the growing conditions at low water levels (winter) will probably not be conducive to such attempts (Alberta Environment, 1987).

The Crowsnest Pass area is noted for sustained periods of high winds (see earlier section for data on wind strength and direction, Figure 5.7 and Table 5.10). This could impact the reservoir fishery in causing wave erosion on the lacustrine cliffs along the lower portion of the reservoir and would increase turbidity. Also, the high winds which frequently occur in the region would not be conducive to prime angling conditions on the waterbody and could result in unsafe conditions detrimental to recreational opportunities.

6.4.4 Downstream of the Dam

As noted earlier, any attempts at fishery mitigation downstream of the dam must focus naturally on those mountain whitefish populations which currently constitute the principal sport-fish population downstream.

The available flow data derived from operational parameters for the reservoir at full irrigation development consist of mean monthly and minimum flow by month for the three downstream stations (Brocket, Below LNID and Lethbridge) (Hagerman, 1987 personal communication). These minimum flows fall at the low end of the discharge component of the discharge/habitat availability relationship cited by EMA (1987b), for mountain whitefish. Hence judgements as to mitigative potentials will have to carefully examine the applicability of this data base.

If a tailwater fishery involving trout is required as a component of riverine mitigation, then significant problems occur with respect to rainbow trout for which mitigation has been suggested (due to isolation from spawning grounds which occur above the dam). First, the high regulated spring release flows (May onward) appear to require the creation of off-channel spawning areas protected from the high flows and implies an engineering/construction cost for a permanent flow barrier.

Further, although the water temperature regime model for reservoir releases is as yet incomplete, the nature of the bottom-water release from the reservoir dictates that the water temperature during the rainbow trout spring spawning season will not approach optimum levels. To provide a tailwater trout fishery the following modifications would be necessary:

1. The temperature regime of the reservoir outlet flow could be modified, although this would require a careful engineering evaluation as to feasibility.

2. If the thermal regime is not amenable to change, then the creation of spawning side-channels would have to be considered downstream of the tailwater zone where optimum water temperatures for rainbow trout spawning are more likely to occur.

3. If a tailwater zone fishery at the projected thermal regime is required there are few options other than to modify, or change, the trout species (e.g. Brown Trout).

4. If mitigation for potential rainbow trout losses downstream, due to the dam, is required and none of the above-noted options for rainbow trout spawning viability can be met, then significant augmentation of the

existing population would be necessary on a continual basis. Obviously, this implies the need for stocking from hatcnery supplies.

This phase of the mitigation plan will need to await the decisions of government as to the applicability of the various options which would be defined by studies and modelling presently underway. Further consideration of this data base by fishery scientists and appropriate agencies will be required in order to more fully define these options for mitigation in the downstream areas.

7.0 SUMMARY AND CONCLUSIONS

7.1 Habitat Losses

It is clear that the construction of the Oldman River Dam as currently designed will significantly impact sport fish habitat and sport fishing in the river basin in which inundation will occur (Table 7.1).

TABLE 7.1
SUMMARY OF HABITAT LOST BY INUNDATION

SPECIES	LIFESTAGE	TOTAL HABITAT (sm)	LOST HABITAT (sm)	%LOST
RAINBOW	JUVENILE	1,520,281	226,865	15%
TROUT	ADULT	297,779	224,676	75%
BROWN	JUVENILE	70,204	29,098	41%
TROUT	ADULT	35,051	20,950	60%
MOUNTAIN	JUVENILE	2,981,469	413,574	14%
WHITEFISH	ADULT	1,569,659	979,243	62%

NOTES: TOTAL HABITAT REFERS TO TOTAL SURVEYED HABITAT IN THE OLDMAN RIVER SYSTEM UPSTREAM OF THE DAM. IT IS NOT THE TOTAL AVAILABLE HABITAT IN THE SYSTEM.

We stress that Table 7.1 presents lost habitat as a function of the total surveyed habitat in the system, not the actual total habitat in the system. Nevertheless, it is apparent from Table 7.1 that the habitat lost is significant.

The impoundment behind the dam will cause a significant loss of holding habitat on all three streams for all three sport fish species assessed. Additionally, a substantial loss of juvenile rearing habitat is shown for brown trout. No significant losses are anticipated to occur for utilized spawning sites for the trout species.

7.2 Upstream

Rivers above the dam and resulting reservoir, particularly the Crowsnest River, are very important sport fishing and habitat areas. While the relative importance of these resources within Alberta have not been quantified in relation to other rivers, they certainly presently constitute resources of the highest value.

Rainbow trout, brown trout and mountain whitefish are the major sport fish species in the affected area; mountain whitefish are the most abundant, while trout are the more valued by recreational fishermen. The Crowsnest River constitutes the most important habitat for, and source of, rainbow and brown trout among the rivers evaluated.

Upstream mitigation techniques are suggested to provide rearing and adult habitat for trout, by the technique of upgrading lower quality riverine habitat sites.

Three specific mitigative techniques have been selected for habitat mitigation upstream of the full supply level of the reservoir. These are as follows:

1) In fast, shallow, river runs, narrow the channel and provide ledges and meanders to reduce the slope and deepen the water. Install bank overhang on the pools at bends.

2) In the slow, shallow, river runs, narrow the channel and provide instream riffles and boulder gardens.

3) The addition of instream cover throughout the river systems by the placement of boulder gardens.

During the aerial reconnaissance, specific potential mitigation sites were identified for each of the Castle, Crowsnest, and Oldman North Fork Rivers. The results of the reconnaissance are not definitive, but do present site-specific river reaches which should be examined further as to specific mitigative works and their design.

For the Castle, Crowsnest and Oldman North Fork Rivers, we have identified three, seven, and two potential areas for site specific mitigation, respectively.

Although some of the habitat areas which have been slated for potential upgrading have been used by mountain whitefish, no great losses in the mountain whitefish populations are expected as indicated by the existing literature. This is because it is currently expected that the mountain whitefish will be able to co-utilize the mitigated habitat which is developed in our plan. Niche stratification for the fish species should allow co-habitation.

Nutrient enrichment, in the form of artificial fertilization through the use of decaying detritus, could be an approach to increasing the low sport fish densities in the Castle River. This river exhibits characteristics of low detrital content, due to the coniferous nature of the head water reaches.

Artificial fertilization is not recommended to be attempted in the Crowsnest River because these waters already have high existing phosphorous levels resulting from municipal effluents. Further enrichment, through artificial means, could eutrophy this river and significantly reduce the water quality.

7.3 Downstream

Downstream of the dam, physical changes in the expected stream flows and water temperature regime, accompanied with expected riverbed changes, will likely alter habitat and impact on the sport fish populations. In addition, populations will be dissected by the physical presence of the dam and movements upstream past the dam will obviously not be possible. Hence the dam presents a major barrier to upstream migration to spawning grounds for the mountain whitefish and the rainbow trout residing in those river sections. The increased minimum flows, however, from the effects of the regulated reservoir may be beneficial, in the long run to mountain whitefish populations.

Downstream of the dam mitigation could take the form of side-channel spawning sites, should they be constructed Figure 7.1. These would be protected from the high flows which will be released from the reservoir for irrigation purposes. If the water temperature regime which will result from these flows is found to be unsuitable for rainbow trout spawning in the tailwater zone, either, spawning sites could be created further downstream where water temperatures may reach mean levels which are more conducive to rainbow trout spring spawning (possibly at the mouth of Pincher Creek) or other trout species could be introduced which might be able to naturally use spawning sites in the tail waters. Until such time as detailed modelling data for the water regime downstream are available, it will not be possible to make definitive judgements in this area. Downstream mitigation possibilities must now be judged to be conceptual; however, once thermal models are available for downstream reaches these data may be employed in the development of potential site-specific plans.

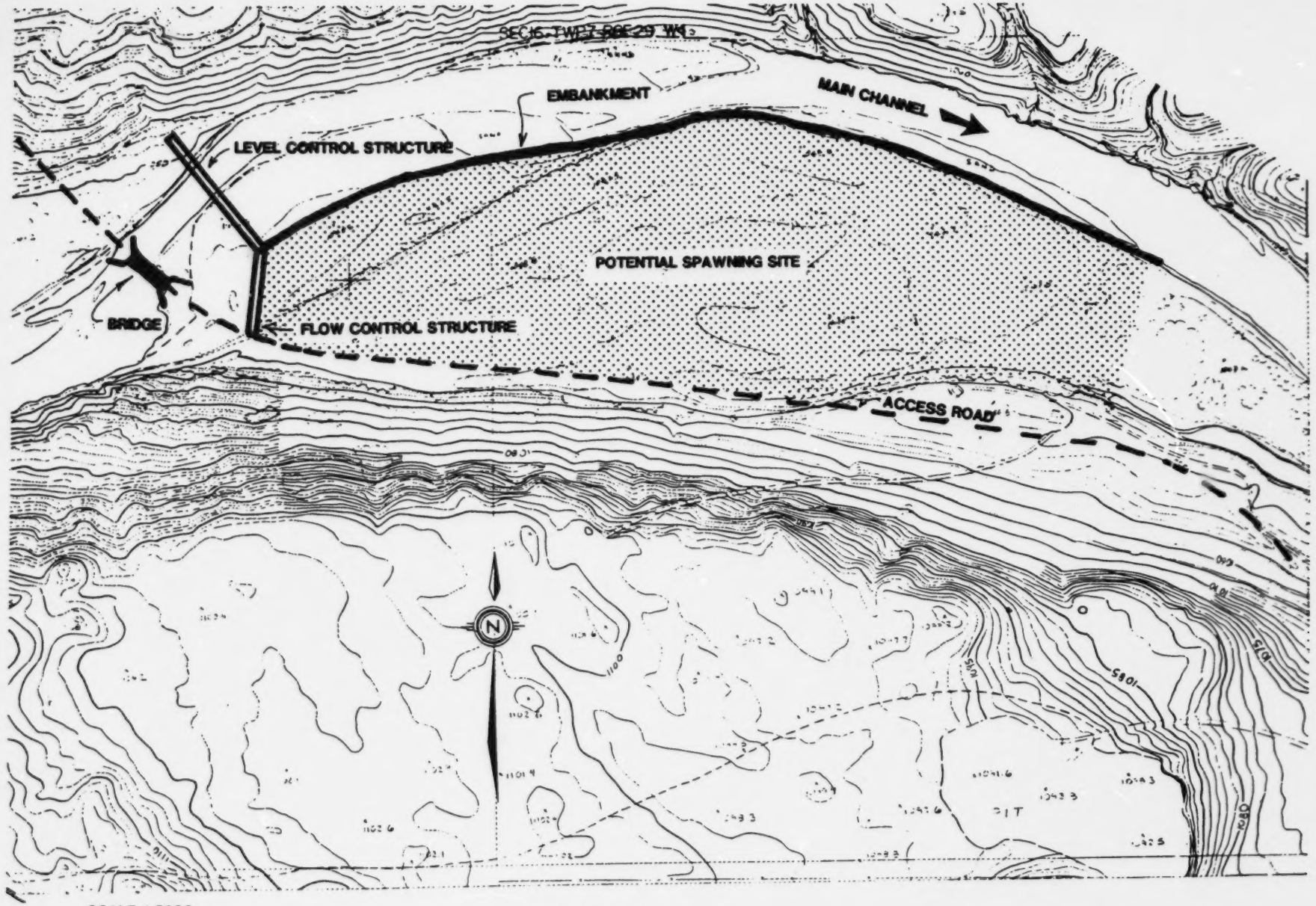

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FIGURE 7.1

POTENTIAL SPAWNING SITE

BELOW DAM

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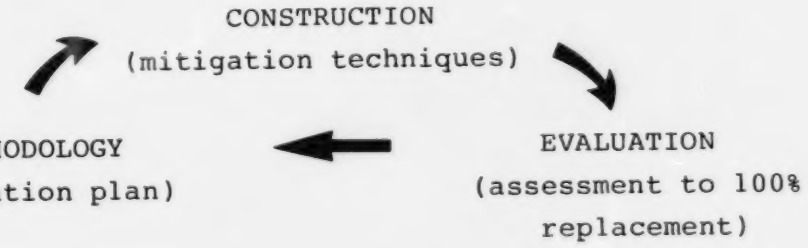
7.4 Reservoir

The development of a viable reservoir fishery would be beset by several severe physical constraints: water temperature, drawdown, wind/waves climate, and turbidity. Stocking would probably be necessary if such a fishery was attempted. Further, the type and amount of fish to be used will have to be carefully examined and will be determined by the availability of suitable specimens. Coarse fish species will naturally tend to dominate reservoir fish populations.

The construction of sub-impoundments to the main reservoir, which are divorced from the detrimental effects of summer water level drawdowns, might be suitable for additional stocked fisheries.

7.5 Discussion of the Strategy

The evaluation of the biological efficacy of proposed mitigation techniques is crucial if one is to properly judge the mitigation proposed. Further, without such post-construction evaluations it will not be possible to ascertain whether or not the commitment for a "no net loss" situation has been met by the mitigation measures which have been implemented.



The schematic diagram represents the process which will be necessary to implement and verify the overall mitigation

plan, the success of which must be measured using biological criteria. While it will be necessary to incorporate an evaluation of the engineering aspects of the works, it must be recognized that most of the in-stream techniques for habitat improvement used to date in North America have had a finite life. The stream and fishery improvements resulting from these in-stream works must be such that they will either survive the decay of those structures or be replaced and maintained. This recognizes a continuing commitment to maintain the habitat and fish populations which are being addressed through this mitigation plan. This commitment could entail significant time spans.

If mitigation techniques, particularly in upstream areas, were begun soon, then biological evaluations could be carried out during the time of construction of the project. This would allow significant refinements to be made to the mitigation methodologies eventually to be used throughout the basin. On the other hand, evaluations of any reservoir mitigation would obviously have to be done after construction.

Major choices are required to be made between the type of mitigation to be used in this mitigation plan. For instance boulder garden placement could be used to create rearing habitat for trout and could result in large areas being created for rearing habitat at a relatively low unit cost. However, if techniques are used which deepen the stream and/or increase the velocity of the waters in order to mitigate for rearing habitat loss, this will entail higher unit costs. Some balance will be required in implementing mitigation techniques so as to properly account for aesthetic values while providing compensation for habitat loss. Since mitigation for adult/holding habitat is likely

to involve increases in water depth, some rearing habitat is likely to be created in the shallower zone of the pool habitat areas.

In order to implement the various mitigation options outlined in this plan it will be necessary for the the appropriate agencies to reach clear decisions among the several alternatives presented. The options are presented by three geographic zones:

(a) upstream
(b) reservoir
(c) downstream

It will be necessary to allocate the proportion of mitigation (of the 100% habitat area required to achieve "no net loss") to each of these zones. This decision will be based on the data to be obtained from the experimental evaluations and in the projected levels of enhancement achieved in specific riverine areas.

(a) Upstream

(i) 15.5 km of the Oldman mainstem will lose significant amounts of critical fisheries habitat. In order to mitigate for these losses upstream of the FSL it will be necessary to decide as to how much (area by life stage) mitigation should be applied in each of the upstream tributaries.

(ii) If techniques for artificial fertilization are to be tested in the Castle River, it will have to be decided whether such an enhancement would constitute part of the "no net loss" equation.

(b) Reservoir

If the reservoir is to be used as a component of the mitigation strategy, the fish species for stocking will have to be decided upon. Further questions of access and safety, from a policy perspective, will need to be addressed.

(c) Downstream

A strategic decision as to the nature of a tailwater fishery is required. If so the water temperature regime of the reservoir outlet, which is presently judged to be inimical to rainbow trout spawning, will have to be a major consideration. Other options could include use of other spawning channels downstream, a change in the trout species or the use of hatchery stock to overcome spawning losses. Downstream mitigation planning for the fishery has now begun and the requisite water quality and fishery data are presently being assembled.

8.0 RECOMMENDATIONS

In the Interim Report on fisheries mitigation dated June 30, 1987, the following recommendations were made:

1. Detailed fishery habitat mapping of those streams outside the influence of the impoundment must be completed so as to better define site-specific locations where it is possible to undertake mitigation. This work should be focused on the presently unmapped sections of the three main upstream tributaries which have existing access for both the construction equipment and anglers, or areas of planned access as identified in the habitat mitigation section of this report.

2. Population assessment of sportfish species on the streams above the full supply level of the reservoir should be assembled immediately as a pre-dam baseline data base. This will require further surveys soon. These data will serve as the baseline against which the biological success of the mitigation techniques which are attempted can be evaluated.

3. Evaluation of the physical habitat mitigation techniques from the fisheries utilization (biological) point of view should be undertaken. The evaluation should be planned so as to cover possible natural fluctuations in sportfish populations. If the physical techniques recommended in the mitigation plan are implemented soon in the upstream area, repeated evaluation could occur before project completion. The type of evaluation reported in RL&L (1987) for the Crowsnest River, incorporating that study's recommended methodology for improvements, is a good example of a biological evaluation of fishery mitigation and is recommended for future use.

4. A pilot or test study of artificial fertilization (using decaying detritus) should be considered for the Castle River. Full evaluation of such work should be incorporated into the mitigation planning, with the realization that sufficient time will be needed for the full potential of nutrient enrichment to be achieved.

As of December 15, 1987, all the above have been acted upon and either completed or are ongoing as active studies.

The following recommendations were also made in the June 30 Interim Report and still stand as useful recommendations on the process and standards of fishery mitigation:

5. Physical modification of riverine habitat to increase its value to the fisheries resource should be designed on firm river engineering principles. Poorly planned and/or executed works may actually cause more damage in terms of lost habitat than they mitigate. Design of physical mitigative works should be a joint undertaking by biological and engineering specialists.

6. Mitigation measures for the fishery, in upstream and downstream reaches of the basin, should take into consideration the availability of materials and equipment during the construction phase in order to achieve efficiencies in implementing the strategy.

7. Options to protect habitat and fish populations during the time of construction should be carefully examined, and, where feasible, opportunities to maintain existing populations of fish should be used.

8. In order to implement the mitigation plan in the downstream area, it will be necessary to await the decisions of government as to the applicability of the various

options which would be defined by studies and modelling presently underway. Further, more intensive discussions with the affected public, notably the native peoples, will be necessary in order to more fully define these options for mitigation.

In order to accomplish these recommended objectives, it is clear that a phased approach to planning, assessment, budgeting and construction should be taken. This would provide for a proper validation of the mitigation techniques to be employed. It is conceivable that this phased approach would require a decade to implement. The Mitigation Plan should strive to achieve flexibility in implementation as the base of data improves.

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APPENDICES

SCHEDULE E

TERMS OF REFERENCE

Project Basis

Service Agreement

CONSULTING

INTRODUCTION

E1. It is recognized that construction of the Oldman River Dam, to provide a flow regulation reservoir on the Oldman RIver, will alter the present habitat available to the fish populations of the area. The fishery in the area is considered to be a valuable resource and the objective of the fisheries mitigation plan will be to attain a condition of no net loss of recreation fishing opportunity as a result of dam construction.

The purpose of this investigation will be to design an overall plan that will attain the objective stated and to detail the component parts of the plan as to location, design, cost and implementation timing.

BACKGROUND

E2 Extensive fisheries inventory information is available in report form as well as preliminary assessments of mitigation options for the area upstream of the reservoir full supply level, the impoundment and the area downstream of the reservoir. The present recreational utilization of the

resourcc has been documented. The attached listing covers the major pertinent reports. The construction schedule, pertinent project design details and reservoir operating specifications will be made available, as required, through Alberta Environment.Candidate components for the fisheries mitigation plan will need to be obtained through discussion with appropriate government staff.

AREAS OF INVESTIGATION

a) Phase 1. This phase should be viewed as a short term component of the mitigation plan and will occur from 1987 until the dam is scheduled to be operational (1991). Activities under the following categories would be considered for the short term plan:

- habitat opportunities related to dam construction or related construction activity
- preparation of stream habitat enhancement plans for the Crowsnest, Oldman and Castle rivers; recommendations for selected habitat improvements to compensate for habitat losses
- assessment and recommendations for the dam discharge system
- development of a reservoir fishery management plan

b) Phase 2. This phase should be viewed as a long term component of the mitigation plan and will occur from 1991 when the dam is expected to be operational to 2001. Activities for this phase would include, but are not limited to the following:

- identification of instream flow needs to allow assessment of optimal flow releases for fisheries purposes to the confluence of the Oldman and Bow Rivers. This information will be supplied by government
- reservoir fisheries management options, including stocking, construction of spawning sites, invertebrate introductions, etc.
- determination of public access site development opportunities
- the costs of design and locations of various projects should be detailed and their relative effectiveness assessed

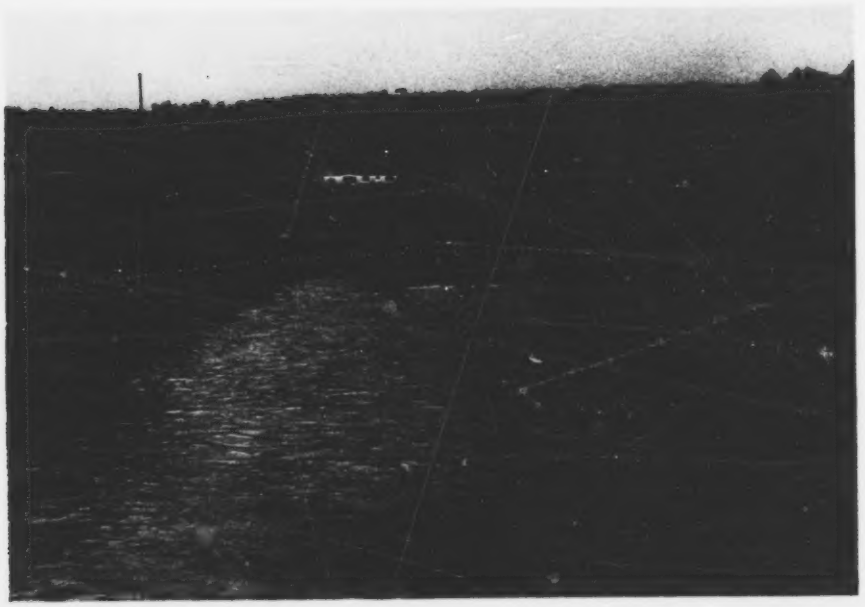
REPORTING

The consultant will provide 10 copies of the draft plan on or before June 30, 1987, for review by Alberta Forestry, Lands and Wildlife and Alberta Environment. A final report will be provided no later than thirty days after approval of the plan by Government. The original copy of the report and of any accompanying plans, specifications, photographs or other documentation will be provided in a form suitable for reproduction.

APPENDIX B

(Photographs)

Castle River



1. Shallow uniform run with no instream cover.

2. Bedrock ledge and pool.

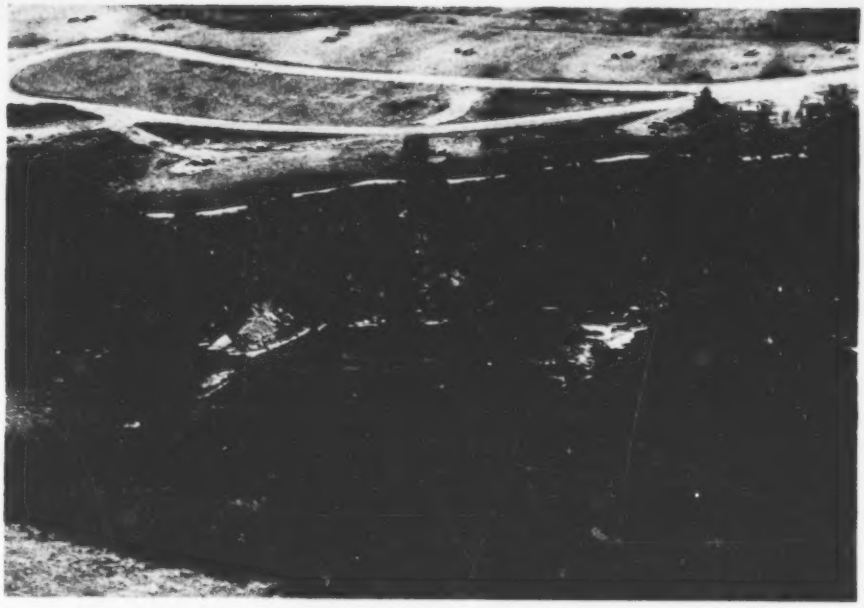
3. Riffle and pool, reach in background lacks instream cover.

4. Castle canyon, with bank overhangs, ledges, pools and chutes.

5. Forground reach requires instream cover.

6. Limited instream cover in a reach of uniform run.

Crowsnest River



1. Bedrock ledges and pools.

2. Limited instream cover upstream of boulder placement of an enhancement project in background.

3. Lundbreck Falls.

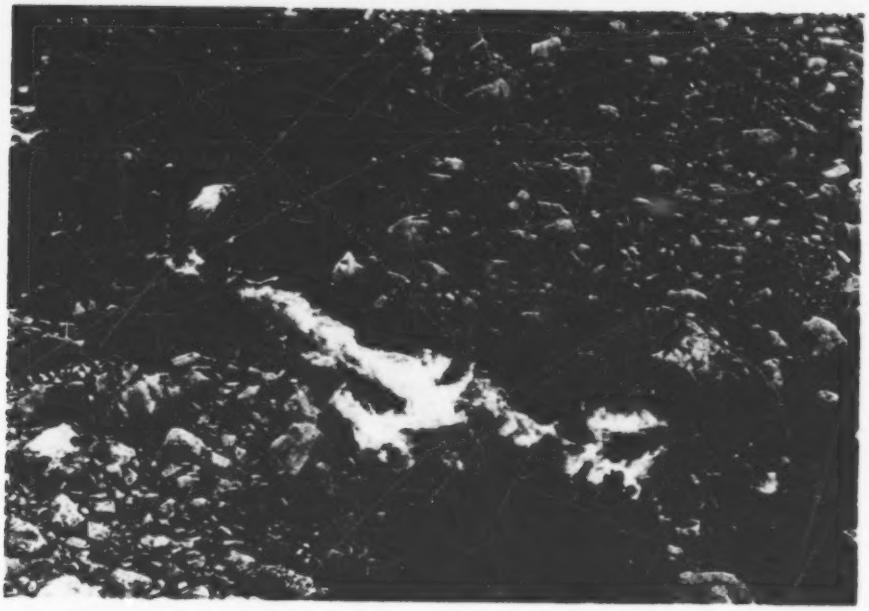
4. Limited instream cover, even with a placement of random boulders.

5. Bank stabilization project with random boulder garden placement.

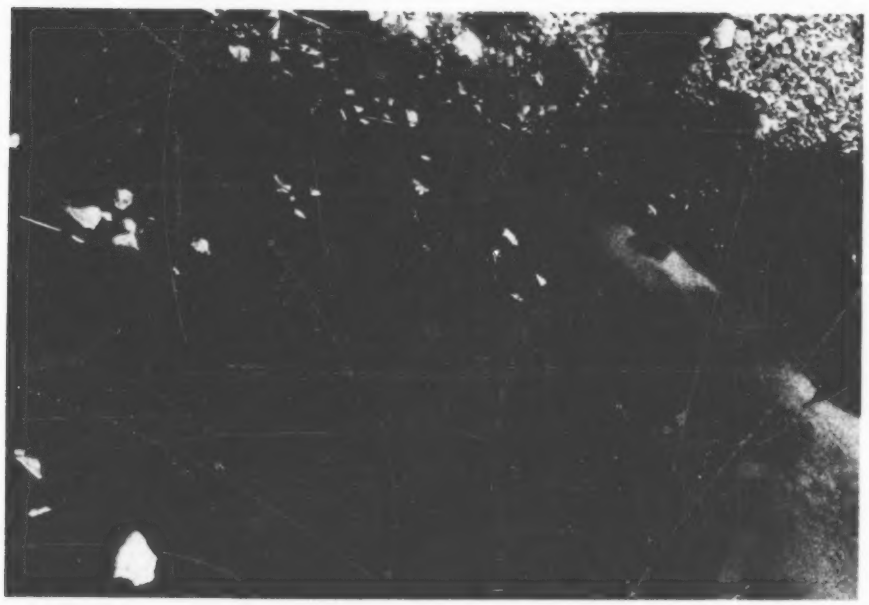
6. Limited instream cover on a reach of uniform run.

7. Bank stabilization with instream cover.

8. Natural boulder garden at the lower end of the Frank slide.



9. Natural boulder garden at the base of the Frank slide.



10. Frank Lake full of sediment.

11. Bank Stabilization with boulder placement.

12. Rehabilitated channel with bank cover, ledges and boulder placement.

13. Channelized reach with no bank or instream cover.

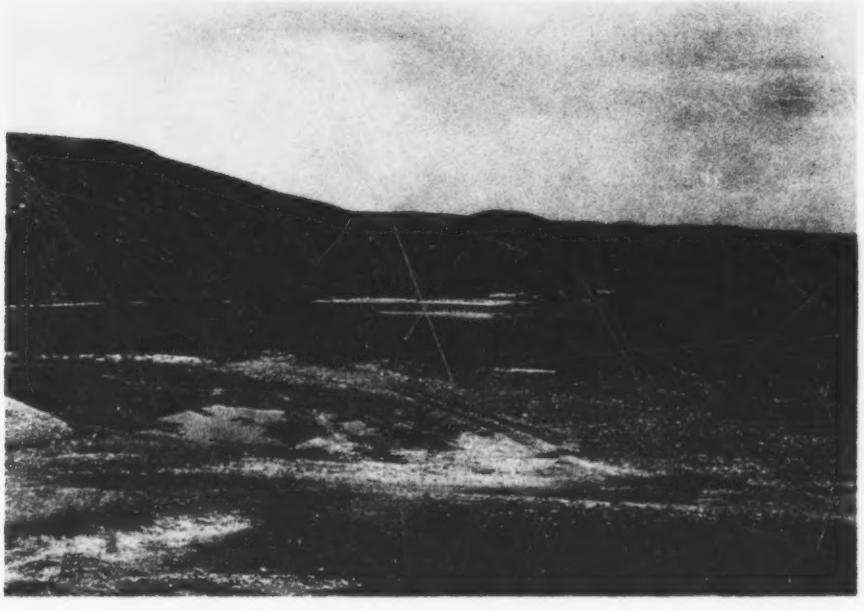
14. Blairmore channelization with the old channel retaining standing water.

15. Channelized reach with limited bank and instream cover. Rip rap and deflector a result of a bank stabilization and stream enhancement project.

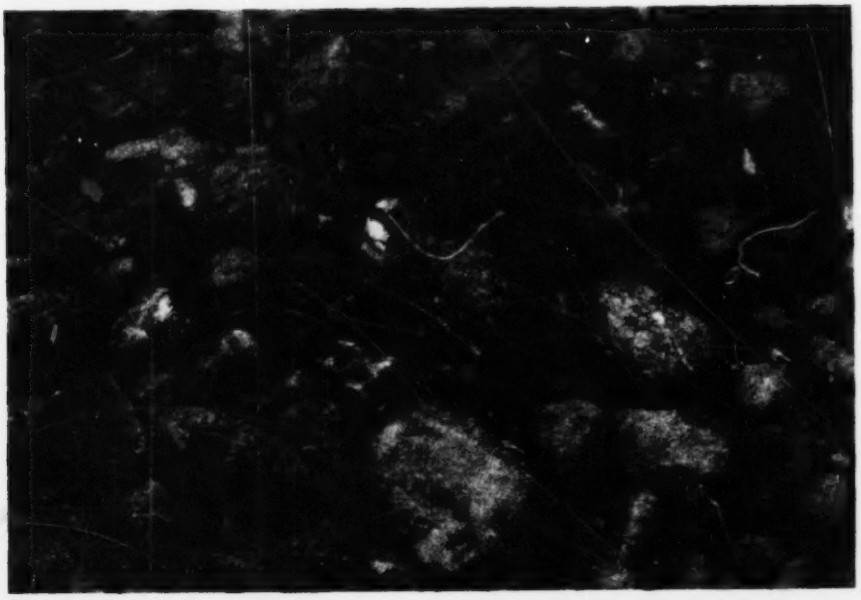
16. Small tributary with mitigation works.

Oldman River

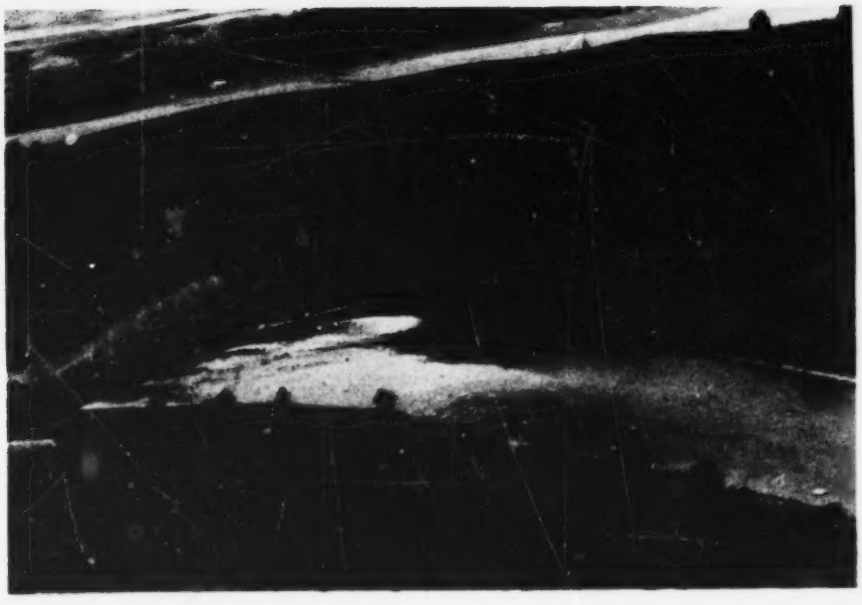
1. Summerview Bridge, the bed and banks are composed of silts not gravels as is typical upstream.



2. The gravel borrow area downstream of the dam which is a site with potential for creating spawning habitat for trout.

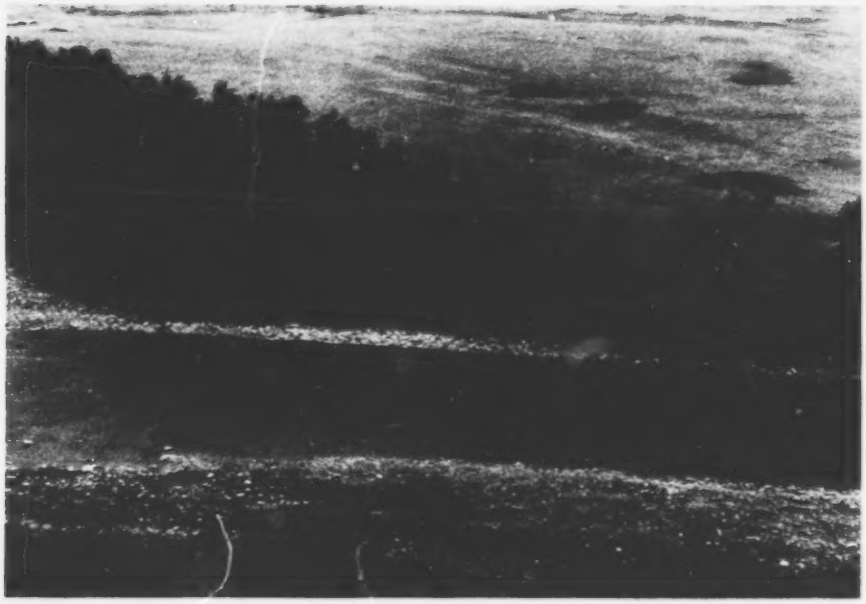


3. The bed of a productive reach.



4. Steep banks limiting access, and limited instream cover requiring boulder placement.

5. Site with potential access from road, however, with limited instream and bank cover.



6. Limited instream and bank cover.

7. Bedrock ledge and pool sequence.

8. Reach with little bank cover and no instream cover.

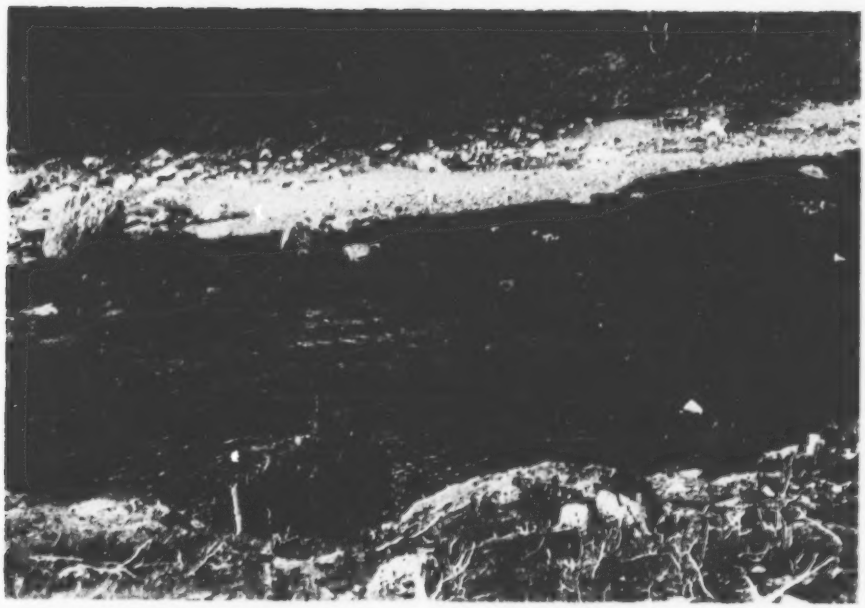
9. Bedrock ledge and pool sequence.

10. Natural reach with good variation.

11. Good boulder garden in run/pool setting.

12. Natural reach with good variation.

Oldman River



13. Some instream cover required.

APPENDIX C

(Fertilization)

APPENDIX C: A LITERATURE REVIEW OF NUTRIENT ENRICHMENT METHODOLOGIES FOR COLD WATER RIVERS

Artificial Fertilization:

The potential for fisheries mitigation in the Oldman, Crowsnest, and Castle Rivers was investigated by the study team. Particular attention was paid to the possibilities for artificial fertilization as a method to compensate for fisheries loss, in a riverine habitat, that would result from dam construction and reservoir filling. The upper portions (above the reservoir) of the Oldman, Crowsnest and Castle Rivers were evaluated.

Background:

Prior to evaluating specific methodologies, the basic functioning of stream systems their trophic and nutrient status within the Oldman River Basin were examined in a general way.

Aquatic systems can be driven by two major energy sources autochthonous and allochthonous. Autochthonous energy is derived from photosynthethetic activity via algae and is predominant source in lake systems. In streams, however, imported allochthonous energy usually in the form of detritus drives the system providing between 50 to 99% of all available food energy to invertebrates and lower trophic forms. This energy is transformed into biomass which is then passed on to fish. Calculations of the amount of energy derived from detritus in various river studies show its importance Teal 1957 (76%); Nelson and Scott 1962 (66%); Fisher and Likens 1972, 1973 (99%).

Egglishaw (1964), demonstrated that there was a close relationship between the distribution and abundance of benthic

organisms and the distribution of plant detritus. In a similar study, Minshall (1967), showed that the most important food source for invertebrates in Morgan's Creek, Kentucky was allochthonous leaf materials, various size fractions of which occurred as suspended material, as components of attached benthic communities on stream bottoms and as whole leaves or fragments.

Primary production can be significant in streams as was shown by Odum (1956), and McIntire and Phinney (1965), but varies with system, altitude and season. As a stream grades into a river the contribution of allochthonous material to its overall energy budget decreases due to a lack of bank-side input and as the organic material flowing through the system becomes finer and more refractory. In general, however, it is accepted by most investigators that small streams draining forested watersheds are basically heterotrophic. They are dependant for their major energy supply on the import of organic matter from the terrestrial systems through which they flow.

The trophic status of the upper Oldman River streams has been evaluated based upon phosphorous loadings. Flow based average values for Total Phosphorous are: 0.017, 0.013, and 0.036 ppm in the Oldman, Castle and Crowsnest Rivers respectively (Hydroqual 1985). Although phosphorous occurs both in simple ionic (ortho-phosphate) and as bound phosphate in soluble and particulate form, total phosphorous in turbulent waters is accepted as being a measure of the biologically available phosphorous (Hynes 1970). On the basis of phosphorous concentrations both the Oldman and Castle Rivers may be considered oligotrophic while the Crowsnest River appears to be mesotrophic. The higher phosphorous levels in the Crowsnest River are thought to result from municipal inputs from the Crowsnest pass communities (Hydroqual 1985). Other than municipal sources, phosphorous

in streams may be derived from rainfall and agricultural runoff. In aquatic systems, because of the rapid uptake and entrapment of phosphorous by plants, it is often thought of as the major factor in limiting productivity. For example, the addition of ortho-phosphate to a rainforest stream in Vancouver Island by Stockner and Shortreed (1978) caused a response in the streams algal biomass. Within 35 days their study showed that algal biomass had risen by a factor of 8 above control site levels and baseline conditions at the application sites. On the basis of these results, they concluded that in their study stream, dissolved phosphorous was the primary nutrient limiting algal production.

Observations on foothills streams in Alberta and British Columbia, appear to suggest that the availability of dissolved nitrogen may be limited. This hypothesis is based upon the abundance of blue-green nitrogen fixing algae such as Nostoc throughout the sub-alpine zone. Such forms of algae do not become a conspicuous part of the stream flora unless nitrogen is in short supply. The projections for nitrate, the biologically most important form of nitrogen, for the Oldman River above urban centers, indicates that under most flow conditions nitrate is essentially absent during the summer months and has a concentration as high as 0.3 ppm during the winter months (Cross and Anderson 1987). These trends in nitrate concentrations are consistant with a nitrogen limited system. The shortfall in nitrate in such systems is more than made up for by the blue-green nitrogen fixers.

Mitigation Methodologies:

Two feasible methodologies for artificail fertilization are available for the upper Oldman River Basin. One, the introduction of nutrient solutions at some point above the reservoir; and two, in-situ river fertilization using

decaying organic matter such as silage, alphalfa, leaves, etc.

The results of nutrient additions in solution form in southern Alberta have been documented for North Drywood Creek, south of the town of Pincher Creek (Crowther and Luoma 1982-85). In this instance, bio-treat waters from the Shell Waterton gas plant caused eutrophication of the creek downstream of the effluent release. The visible effects of nutrient addition was to cause massive blooms of benthic attached algae and substantial increases in benthic invertebrate biomass and population densities. Increases in the order of 16 to 20 times backgroud levels were noted in invertebrate numbers downstream of the effluent. Local reports of resident trout caught by anglers indicated that they were slimy and tasted unpleasant.

Following a review of water quality data, it was recommended that Shell reduce phosphorous usage in the bio-treat ponds since it appeared from the data that too much was being applied and that the excess then entered the stream. Recommended levels for total phosphorous in the stream below the release were set at 0.02 ppm based on upstream concentration levels. Phosphorous concentrations in North Drywood Creek below the effluent release until this recommendation was made had been as high as 0.07 ppm. The water quality data and the presence of blue-green algae above the plant suggested to the study team that nitrogen may have been limiting so no recommendations for its removal from the effluent stream were made. Upon implementation of these recommendations by Shell, the stream recovered to near background site conditions below the effluent release over a two year period (Crowther and Luoma 1982-85).

Suggestions have been made to utilize Shell bio-treat waters to artificially enrich the Oldman tributaries above the

three rivers reservoir. Nutrient solution addition is not recommended based upon our experiences at North Drywood Creek. The findings of Cowther and Luoma (1982-85) are consistant with those of Stockner and Shortreed (1978) and indicated that such additions particularly of phosphorous will cause substantial increases in benthic algae production. If this occurs the original habitat and trophic status of the stream will change causing a deterioration of sports fisheries rather than an enhancement which is the aim of this program.

The second method available to artificially fertilize the upper Oldman River streams ie.) the in-situ use of decaying organic matter bears considerable merit and attention. The method would employ large stream cross-sectional envelopes constructed of a heavy "Vexar" type material with fine meshing fixed to the bottom by stakes and place at the down-stream side of riffles. Into the envelope decaying organic matter such as silage or alphalfa would be placed. The theory being that the organic matter would be colonized by naturally occurring aquatic bacteria and fungi which would then produce a palatable food source for benthic invertebrates thus increasing secondary benthic production.

The main type of detritus in the upper Oldman basin at present is coniferous which breaks down very slowly under bacterial and fungal action. Barlocher and Oerti (1978) in southern Ontario streams found that 140 days of stream conditioning were necessary for coniferous needles before invertebrate feeding began. This long conditioning period was suggested to be caused by the presence of anti-fungal and bacterial chemicals such as turpentine in the breakdown products and leachate. The presence of such chemicals is thought to prevent the usual colonization cycle necessary to convert the organic matter into animal protein (Barlocher and Oerti 1978). The streams in the upper Oldman River

basin are probably much cooler than those studied in Ontario which may cause a lengthening of coniferous conditioning past 140 days. This factor plus a lack any substantial deciduous input likely cause these streams to be unproductive from a benthic invertebrate and hence fish point of view.

The emplacement of decaying organic matter in the streams should not only increase benthic standing stocks but also should produce an increase in stream insect drift. Drifting insects are a preferred food source for visual surface feeding fishes such as trout (Waters 1961, Kovalak 1978a,b,c). Studies conducted by Mundie et al., (1973), and Williams et al., (1977) have shown that artificial increases in stream drift (by agitation) were capable of increasing fish production in smolt salmon in comparison to both pellet fed and natural populations.

Sources for organic material for colonization envelopes would be local farmers and therefore cost effective. The envelopes should be designed to be re-usable so that re-occurring costs do not accrue to the operational agency.

We would suggest that a pilot project be completed using this technology on the Castle and Upper Oldman Rivers to test its overall effectiveness. That the technique is viable is not questionable since numerous studies have shown on a smaller scale that benthic production can be enhanced by increasing the availablity of detritus of the correct type (Sedell et al., 1974; Iversen 1974; Cummins et al., 1973) The relationship between invertebrate drift and detritus in the Oldman River system was studied by O´Connell and Davies (1977) who found that drift density was directely correlated to amount and type of detritus available.

If this technique is to be employed, access to fertilization

sites should be strictly controlled. This is thought to be necessary since sports fish species will likely be attracted to the area and will be extremely susceptible to angling pressure. If access is not to be limited, a catch release program should be instituted and fishing restricted to barbless lures or fly only.

Other types of artificial fertilization have been attempted in the past using commercial fertilizers, grain and deciduous leaves. These types of programs were not totally effective or were too costly to be employed on a regular basis.

No fertilization program should be undertaken on the Crowsnest River until phosphorous loadings to the stream from municipal wastes can be reduced. High phosphorous loadings plus enrichment by means of detrital packages may push the river into the eutrophic classification. If this were to happen the species complement for fish may change to produce more of the coarse varieties such as suckers, to the detriment of the sports fisheries presently found in the river.

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